A MANUAL OF DRAWING.

COOLIDGE.

Assistant Professor of Mac.

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FIRST THOUSAND.

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PREFACE.

THE officers of instruction in the Department of Machine Design of Sibley College, Cornell University, in addition to a great many other kindred things, are charged with the responsibility of instructing the Sophomore, Junior, and Senior Classes in the art of commercial mechanical drawing.

We recognize the fact that the student is often unnecessarily perplexed, distressed, and even retarded in the advancement of his work because he has no single, definite, or comprehensive system which he can follow in his drawing.

Thus the object of this Manual is to put into permanent form a single and standard drafting-room system which will tend to alleviate unnecessary burdens thrust upon the student.

It is conceded beforehand that the student is not and should not be held in the same *status* as a full-fledged and experienced commercial draftsman. Therefore he should be informed of more than one route which will take him to the same destination.

That information can be imparted by informal talks given in the class-room or lecture-room. But a single and definite system could and should be followed, to facilitate advancement in too short a course in drawing; to give him, as far as possible, the atmosphere and sensation of the commercial drafting-room; and, if nothing else, to teach him one good system well.

The system that has been evolved, and embodied in this book, is intended to be the average of the Drafting-room Systems which are in use in the United States at the present day, and is fully substantiated by the solicited data and information that have been received from about one hundred and thirty of the largest concerns in the United States in various lines of manufacturing.

A cursory glance through the book will disclose blank pages alternating

with the printed ones in the front part of the book and with the illustrated ones in the back part.

The drafting-room system as elaborated in this book is, by virtue of its predesigned scope, by no means complete.

It thus devolves upon the instructor to give and the student to note on the blank pages what is left out in the text.

It was the primary object of the writer to elaborate, as described above, only on what is produced by means of drawing-instruments. He soon realized, however, the fact that that is only the end of things, and the beginning cannot be detached when it is probably the most important part of the technic of mechanical drawing. Therefore the writer has discussed in detail the salient points in the selection, treatment, and adaptation of the drawing instruments and materials that are used in a commercial drafting-room.

The pressing need of this imperfect little book to assist in advancing the interest of the student, was the sole incentive which caused the author to write it. He will be repaid if its mission is partly fulfilled.

He is under obligation to Professor John H. Barr, the head of the Machine Design Department, for reading the manuscript and for rendering substantial assistance which aided in the completion of the book.

He desires especially to thank Mr. Sanford A. Moss, who has collaborated with him in advancing a set of standard drafting-room conventions for the use of the Machine Design Department.

Thanks are also due to all others who have in any manner lent assistance or given encouragement.

C. E. Coolidge.

Ithaca, N. Y., September, 1902.

Manual of Drawing.

PART I.

MATERIALS AND INSTRUMENTS.

The materials used in drawing may be divided into two distinct parts. One part would represent the materials on which drawings are made and reproduced before any substances are applied to make that contrast which pronounces it a drawing for the manufacturer or builder in commercial mechanical lines, to produce, by means of it, that which has utility and a commercial value. The other part would represent such substances as are necessary to apply to the drawing materials, for the purpose just described.

The materials on which drawings are made and reproduced would include drawing-paper, bond-paper, tracing-paper and -cloth, print-paper, etc.

The substances applied for making drawings would include lead, ink, chemicals for prints, etc.

The instruments and other accessories which

are used in applying the different substances to the surfaces of drawing materials must be selected for their adaptation to the execution of a commercial mechanical drawing.

Commercial mechanical drawing-instruments and other accessories would include the drawing-board, T-square, compass, dividers, etc.

MATERIALS ON WHICH COMMERCIAL MECHANICAL DRAWINGS ARE MADE AND REPRODUCED.

Commercial mechanical drawings are, at the present time, usually made first in pencil on inexpensive drawing-paper and then traced with ink on tracing-paper or -cloth; and, finally, printed on chemically prepared paper.

Occasionally drawings are penciled and inked on a good quality of white or brown paper, or bond-paper and prints are taken from the inked bond-paper drawing.

Drawing Paper.

The *ideal* drawing-paper should be of tough fiber, uniform thickness and surface, neither repel nor absorb ink before or after it is rubbed with an ink-eraser, and take the ink without wrinkling the surface.

Whatman's Hand-made Paper. Whatman's hand-made paper approaches most nearly the ideal drawing-paper. It is about the most expensive drawing-paper made, and for that reason it has a very limited use in commercial establishments.

Manilla Paper. Manilla wrapping-paper is a brown paper and one of the cheapest brands of paper made. It should never be used for finished inked drawings.

Duplex Paper. Keuffel & Esser's Duplex (or equivalent) drawing-paper is a brown- or cream-colored drawing-paper and is a little better quality than the average commercial grade. It will bear a fair amount of careful rubbing and inking.

Egg Shell Paper. Egg-shell paper, with a linen back and rough surface, is occasionally used for a drawing made to stand out in bold relief for pictorial effect. It is a very durable paper and will bear very rough handling.

Bond Paper. Bond-paper is a thin and comparatively translucent white paper which has the distinctive advantage that the original drawing can be directly printed from on print-paper or cloth, and thus avoid mistakes of omission and commission made in tracing from a drawing.

Bond-paper is very easily wrinkled and can be rubbed through very quickly. Therefore

it requires most careful handling; and an inked drawing on bond-paper should not, as a rule, be rubbed with anything except a fine ink-eraser. The extended commercial use of bond-paper is increasing.

Cross Section Paper.

Cross-section paper, whose checks are conveniently spaced, has the advantages found in bond-paper, and the added advantage of drawing on it without the assistance of a scale.

Laying Paper on Board.

Drawing-paper, when it comes in rolls, should usually be laid with the convex side next the drawing-board, and the water-mark should always be on top.

Stretching Drawing Paper.

Drawing-paper is occasionally stretched on the board when it is not to be taken off for some days; but after it is taken off the paper usually contracts and the scaling is affected.

The paper is stretched on the board in the following manner: first, clip off the corners so that the four edges can be folded over for three fourths of an inch; second, wet all the surface except the turned edges, with a sponge; third, lay the wetted surface next to the drawing-board; fourth, smooth the paper by rubbing from the center out to the edges; fifth, glue down the edges with very strong gum arabic or like material.

Mounting Drawings.

A paper drawing may be longer preserved

by mounting on straw-board and varnishing its surface with white shellac

Tracing Paper.

Tracing-paper is a firm and transparent paper having a smooth and glossy or oily surface, and can be easily printed from on print-paper. It should be of tough fiber, uniform thickness and surface, neither repel nor absorb ink before or after it is rubbed with an ink-eraser, and take ink without wrinkling the surface.

Tracing-paper should not generally be used when permanency of a drawing is the chief object.

Tracing Alternate Positions.

Tracing-paper is used somewhat for tracing alternate positions of a piece of mechanism, in order to facilitate a design, when the relation of the piece of mechanism to the other parts of the machine is known.

Tracing Cloth.

Tracing-cloth or -linen should have one of its surfaces well glazed and no open pores. It possesses the same properties and uses as tracing-paper, besides being more permanent. It has a more extensive use commercially.

Tear off Edge.

Before tracing-cloth is laid on the board the

wrinkled portion along the edges should be torn off and its surface should be stretched smooth. (Tracing-cloth will tear straight parallel to its edges only.)

Advantages and Disadvantages of Glazed and Unglazed Sides.

There is considerable discussion and contention as to whether the glazed or unglazed side of tracing-cloth should be used. There are advantages and disadvantages in using either. It must be admitted that the glazed side was primarily intended for use; that drawing-ink, especially red ink, when used, will eat deeper into the unglazed surface with consequent difficulty in rubbing; that it is usually rolled with the glazed side in, which would naturally bring the glazed side on top, as the convex surface is placed next the board; that the tracing does not curl so much when inked on the unglazed side as on the glazed side; and also that the tracing will eventually smooth itself out when inked on the glazed side if placed in the drawer with the glazed side down. Therefore the writer must insist that, from his present knowledge and past experience, no change from ancient customs should be made unless a drawing is penciled on the cloth, when it is absolutely necessary that the unglazed side should be used in order to see the pencil-lines clearly.

Pr ration f Surface of Tracing Cloth.

Before using tracing-cloth, and especially if its surface has been exposed to the air, it should

be rubbed with a fine powder or blotter and then brushed off thoroughly.

Effect of Moisture on Tracing Cloth.

Tracing-cloth is very susceptible to moisture in the atmosphere, and it will become taut or loose with a change of weather.

Water will ruin tracing-cloth, and care should be taken that perspiration from the hands is prevented from coming in contact with its surface.

The sizing can be dissolved or soaked off, and the linen left makes a very desirable pen-wiper.

Cleaning Tracings.

Tracings can be cleaned with gasolene, ether, benzine, or any highly volatile substance.

Sheet Celluloid.

Sheet celluloid is used in the same manner as tracing-paper for tracing alternate positions of a piece of mechanism. It is more durable than either tracing-paper or -cloth, and is handled more easily.

Print Paper.

Print-paper should be of tough fiber to admit of considerable handling, and should print quickly with clean-cut lines in ordinary sunlight.

To Print from a Drawing.

To print from a drawing proceed as follows: Lay the drawing in the printing-frame with the

ink-lines next the glass; then lay the sensitized surface of the print-paper next the drawing; expose for a suitable time to the sunlight and then remove the print and place in a fixing solution for a suitable time, which will vary with the kind of print-paper used.

Blocking Out.

If there are certain lines, figures, etc., on the tracing that are not desired on the blue-print, they can be retained on the tracing and left off of the blue-print by placing a piece of opaque paper over them when printing.

Principle of Printing.

The principle involved in printing lies in the chemical change after the sensitized surface of the print-paper has been exposed to the light and passed through a fixing solution. That part of the surface of the print-paper under the inked lines, figures, etc., on the drawing is shielded more or less (depending on the color of ink used) from the light; therefore after the fixing solution is used, the necessary contrast which is desirable on the print obtains. It is thus evident, from the known relation of color to light, that, when the most distinct lines are required on the print, the blackest and most opaque ink must be used to entirely exclude light from the surface of the print-paper.

Use of Colored Inks.

Colored inks, which are of course not so impervious to the light as black ink, are occa-

sionally designedly used on drawings to give a less distinct line on the print; but, for commercial use, thin black lines of different character from the lines of projection on the drawing are far more desirable, for many reasons which are noted through the text, and serve the same purposes that colored lines usually do in commercial mechanical drawings.

In a *résumé* of the foregoing it is evident that the time of exposure of the print-paper to sunlight varies according to the sensitiveness of the chemicals used; with the materials upon which the drawing is made; with the substance applied in making the lines, figures, etc., on the drawing; and the intensity of sunlight—which is usually more effective in winter than in summer—or artificial light.

Printing by Electric Light. Apparati of several designs have been devised in which the electric light is used for printing, and they are especially convenient in cloudy or stormy weather.

Care of Print Paper. All print-paper should evidently be as *fresh* as possible; and, when not in the printing-frame, it should be kept from the light in a covered can or case placed in a dark room.

Shrinkage of Print Paper. It must be borne in mind that print-paper usually un-uniformly shrinks, and therefore it must *never* be scaled for actual dimensions.

Blue Print Paper. Blue-print paper is decidedly the most used

commercially. It produces a white line on a blue field.

Over Exposure. The field of a blue-print darkens according to the amount of exposure; and, as none of the black drawing-inks are absolutely opaque, the value of a print can be annulled by over-exposure.

Fixing. After exposure to sunlight, blue-print paper is immediately immersed in water (which is the fixing solution), and then all loose substances on the printed surface should be washed off with a hose filled with water under pressure. The print should remain in the water for at least ten minutes.

Time of Exposure. The ordinary blue-print paper requires about four or five minutes' exposure to bright sunlight.

Quick Blue Print Paper. There is a *quick* blue-print paper which requires about two minutes' exposure in bright sunlight when printing from a drawing made on tracing paper or cloth or their equivalent.

Printing from Bond and Cross Section Paper. In printing from bond paper and cross-section paper, a longer exposure to the light is required than for printing from tracing-paper or tracing-cloth.

Blue Print Cloth. Blue-print cloth is printed in the same manner as blue-print paper. It is much more permanent than blue-print paper, as it will bear rougher usage.

White Print Paper. White-print paper produces a blue line on a white field, and is treated similarly to blue-print paper.

Black Print Paper. Black-print paper produces a black line on a white field and is immersed in a chemical bath first, if there is no chemical developer in the coating of the paper. It is afterward carefully washed in water in the same manner as blue-print paper.

Brown Print Paper. Brown-print paper produces a white line on a brown field. It should be immersed in a fixing solution and then washed in water in the same manner as the other print-papers.

Mounting Prints. A print may be longer preserved by mounting on straw-board and varnishing its surface with white shellac.

SUBSTANCES APPLIED FOR PRODUCING LINES, FIGURES, ETC., ON COMMERCIAL MECHANICAL DRAWINGS.

All substances which are used on the surfaces of drawings should be selected for their adaptation to the purpose. No inferior grades should be used.

Pencils.

A good drawing pencil or "lead" (misnomer and conventional) is essential for producing plain, clean-cut, and uniform lines.

The pencil should be made of a uniform grade of material throughout; and a suitable grade of hardness should be selected for the type of drawing which is to be made.

Soft Pencil.

A soft pencil draws smoother, easier, and faster than a hard pencil.

Grade of Pencil.

A drawing which is to be either inked or traced over, should be made with a soft pencil of HHH or HHHH grade. A drawing made for permanent use and not to be inked or traced, should be made with a HHHHHH to HHHHHHHH grade pencil.

Inks.

Black drawing-ink should be opaque, water-proof, and non-decomposable; and should flow freely, dry quickly, and not eat into the surface of the drawing material.

Black drawing-ink can be prepared from stick India ink; but it is more convenient when purchased in the bottles of the prepared commercial water-proof drawing-ink.

Never Thin Drawing Ink.

The commercial prepared water-proof drawing-ink must *never* be thinned. If the ink does not flow satisfactorily, examine the pen for the source of the trouble, or, if the ink has actually changed (which is almost invariably not the case), procure another bottle.

Red Ink.

Red or carmine drawing-ink—used only when

absolutely necessary—should be water-proof and non-decomposable. It should flow freely, dry quickly, and not eat into the surface of the drawing material.

Care of Ink.

All ink, when in use, should be kept in an open drawer, within convenient reach, or at a sufficient distance away from the drawing to prevent it from being upset on the drawing.

Substances for Preparing a Surface to be Inked after it is Roughened.

When the fibers of a surface have been torn up by careless rubbing, the prepared varnishes painted on it, or the rubbing of the affected surface with soapstone, hard beeswax, bone, or the end of the finger-nail, will effectually prepare it for inking.

Substances used in Preparing and Altering Blue Prints

The sensitizing chemicals for blue-prints are prepared from several formulæ in varied proportions.

Sensitizing Solution for Blue Print Paper.

A good sensitized surface is prepared as follows: In a dark room, make a solution of

Citrate of iron and ammonia ...	1 part.
Water	5 parts.

Then make a solution of

Red prussiate of potash	1 part.
Water	7 parts.

Mix equal parts of the two solutions and apply with a sponge, for about two minutes, to a paper having a hard and smooth surface; then drain off the superfluous liquid and hang up to dry. The paper thus prepared will have a bright yellow hue.

The sensitizing solutions can be kept separately for a long time, but when mixed must be kept from the light.

Altering Blue Prints.

Soda, potash, quicklime, or any alkali in solution with water and a little gum arabic added to keep the liquid from spreading on the paper will produce a white mark on the surface of a blue-print. Such solutions are used for making alterations in the print.

Chinese white and other commercial pastes are also used for making alterations; but the writer believes that there is nothing more satisfactory for the purpose of making corrections or additions on a print than to use black ink on a light print and red ink on a dark print.

INSTRUMENTS AND OTHER ACCESSORIES USED IN THE EXECUTION OF MECHANICAL DRAWINGS.

The proper selection of instruments is of prime importance. It is universally conceded by first-class draftsmen that good instruments are absolutely essential for the best execution of drawings in the shortest time.

The term "good instruments" does not necessarily imply that a draftsman should have all the new-fangled specifics that are afloat on the market; as, section-liners, dotters, etc. A *good instrument,* legitimately interpreted, is one which is indispensable and of the best grade.

Drawing Board.

The drawing-board should be made of soft and well-seasoned wood of uniform grain; should have two adjacent edges straight and at right angles to each other; should have its working surface very slightly crowning in the center; and should be designed to allow for the changes due to atmospheric conditions.

Working Straight Edge.

If a permanent working straight-edge on the board is desired, a heavy cast-iron or steel strip may be securely fastened to it.

Testing the Working Edge.

The truth of the straightness of the working edge of the board can be tested by applying a standard straight-edge.

T Square.

A T square of the best grade and design should have a fixed head and blade, with ebony-lined edges.

The blade should be dovetailed or let into the head, but the upper surface of the head should always be flush with the working surface of the drawing-board.

If the blade is fixed to the head with screws, not less than five screws should be used.

Double Head. As a rule, adjustable heads are undesirable; but a design having a double head is practicable, and is recommended when one head is permanently fixed, as specified above, and the other detachable, adjustable, and fastened with two binders.

Beveled Blade. The blade should have its working edge beveled to not over one sixteenth of an inch thick, and the ebony lining well secured.

Celluloid Lining. Experience has proved that the celluloid lining, while possessing some slight advantages, warps and loosens, which fact makes it unsatisfactory.

Testing the Edge of Blade. To prove the straightness of the edge of the T-square blade, proceed as follows: first, draw with it a line; second, turn it end for end and place the edge of the blade to exactly coincide with each end of the line which was drawn; third, draw another line; fourth, observe the coincidence of the lines which were drawn, to prove the truth of the straightness of the edge.

Testing Head. The truth of the straightness of the head can be tested by applying a standard straight-edge.

Pear Wood T Square. A good pear-wood T square, designed as above, makes a cheap and altogether decent instrument.

Nickel Plated T Square.

A nickel-plated steel T-square has the decided advantage of maintaining its truth; but its surface gathers dirt and smuts the drawing, which fact makes it less desirable than the other types.

Parallel Straight Edge.

A parallel straight-edge, which is fastened to a cord or wire running in grooved rolls which are secured to the corners of a drawing-board, replaces the T-square, and, consequently, the the working edge on the drawing-board.

There are other arrangements of the parallel straight-edge, and nearly all of them are most desirable.

Triangles.

Transparent Triangle.

The transparent triangle appears to be the most popular triangle used at present. It is subject to change in planeness and accuracy, and the very best material used in its manufacture is none too good. It possesses the advantages of not obstructing the view of anything on the drawing when in use, and of keeping a drawing cleaner than other triangles.

Hard Rubber Triangle.

The hard-rubber triangle warps somewhat, but usually keeps its planeness longer than the transparent one, and smuts the drawing more.

Pear Wood Triangle.

The pear-wood triangle is cheaper, but subject to change due to atmospheric conditions. It does not smut the drawing like rubber.

Nickel Plated Steel Triangle.

The nickel-plated steel triangle maintains its planeness and truth, but, like other steel instruments, it gathers dirt and smuts the drawing.

30° × 60° and 45° Triangles.

The 30°×60° and 45° triangles are most commonly used; but there are a large variety whose sides make other angles with each other.

Inside Edge Cut Out and Beveled.

If the central portion of a triangle is cut out, the inside edge may be beveled on one side to facilitate handling when it is transferred from one part of the drawing to another.

Inserted Knob.

An inserted knob is also used, and perhaps is more convenient than the beveled edge for picking up the triangle.

Combination Triangle.

The combination triangle designed by D. J. Kelsey, New Haven, Conn., combines all the functions of the common 30°×60° and 45° triangles, except the drawing of parallel lines, lines perpendicular to each other, and a line making 75° with the horizontal. It has the inserted knob and generally takes the place of 30°×60° and 45° triangles, when used in combination with the T square.

To Draw 30°, 60°, and 90° Lines.

By properly combining the T square and the 30°×60° triangles, lines can be drawn making 30°, 60°, and 90° with the horizontal and vertical.

To Draw 45° and 90° Lines.

By properly combining the T square and 45° triangle, lines can be drawn making 45° and 90° with the horizontal and vertical.

To Draw 15° and 75° Lines. By properly combining the T square, 30°× 60° triangle, and 45° triangle, lines can be drawn making 15° and 75° with the horizontal and vertical.

To Draw Parallel and Perpendicular Lines. By properly combining a triangle and T square or the 30°×60° and 45° triangles, parallel and perpendicular lines can be drawn.

To Prove 90° Angles. Both triangles are proved for the truth of their 90° angles as follows: first, place the short side of the triangle against a straight-edge; second, draw a line; third, reverse the triangle and draw another line directly over the first; fourth, observe the coincidence of the lines, which will prove that the angles are correct.

To Prove 30° and 60° Angles. The 30° and 60° angles can be proved for their truth as follows: first, place the short side of the triangle against the edge of the T-square blade; second, draw through a point, with the 60° side of the triangle, the two lines made with the triangle after it is turned first on one side and then on the other; third, draw a horizontal line across the extremities of the lines just made; fourth, measure the triangle, formed by the lines drawn, to prove the equilateral triangle which obtains for a true 60° angle.

To Prove 45° Angles. The 45° angle can be proved for its truth as follows: first, place one of the short sides of the triangle against the edge of the T-square

blade; second, draw through a point, with the 45° side of the triangle, the two lines made with the triangle after it is turned first on one side and then on the other; third, draw a horizontal line across the extremities of the line just made; fourth, measure the triangle, formed by the lines drawn, to prove the isosceles triangle which obtains for a true 45° angle.

The triangle should always be used with its working edge next to the light to avoid shadows.

Working Edge to Light.

The working edge for a right-hand person is naturally on the left; and the drawing-table should be arranged accordingly, in order to have the light on the proper side of the triangle.

Light for Drafting Room.

Northern exposure and diffused light through skylight windows is undoubtedly the ideal light for a drafting-room.

Scale.

Triangular Boxwood Scale.

The scale is made in many forms, but probably the triangular boxwood scale is the most popular. It is easily read and manipulated, and will admit of combining, in one scale, all the graduations which are usually used in making any particular type of commercial mechanical drawing.

Scale Guard.

A scale-guard should be used with the triangular boxwood scale to obviate the usual expe-

rience of inconvenience from placing the scale on the wrong side when it is in use.

Nickel Plated Sheet Steel Scale.

Undoubtedly the nickel-plated sheet-metal steel scale conduces to most accurate work, which is vitally essential in well-made drawings.

Marking off Distances.

The marking off of distances is greatly facilitated by running the pricker-point or pencil-point down the indents on the steel scale which indicate the graduations.

Turning Scale.

As there are but two graduated edges on the steel scale, the annoyance experienced of frequently turning the scale, is eliminated.

Reflecting Light.

The ancient cry that the eyes are injured by the reflection of light from the nickel-plated steel scale, has been unsubstantiated. The writer sees no reason why a steel scale should injure the eyes more than a white enameled one.

Flat Boxwood Scale.

A flat boxwood scale with beveled edges has less pitch on its sides, and, for that reason, is considered by some to be more quickly and easily read than any other form. It is not, however, as readily manipulated as any of the others.

Scales in Sets.

Both sheet-steel and boxwood scales can be obtained in sets to suit the requirements, but the former scale is recommended as superior to all others.

The ordinary scale was never designed for a

straight-edge or ruler, or for any other purpose than to take distances from.

Scale to be Used. When a drawing is made on reduced scale, the full size scale *should not* be used; but the particular scale which is arranged and adapted for the purpose. For example: a drawing may be made one fourth size in English measure, or its equivalent, three inches to the foot, which indicates that a graduation is to be found where every three inches in length is marked in feet; and also, one three-inch length is subdivided into twelve equal parts which are marked inches.

Scale Terms. Such terms as $\frac{1}{4}$ scale or size and $\frac{1}{4}$ inch to to the foot must not be confounded when the proper graduations are being sought on the scale. A moment's reflection will make it clear that the former stands for three inches to the foot, and the latter for one fourth of an inch to the foot; and their respective scales will be graduated as indicated above.

To Prove a Scale. A scale can be proved for accuracy as follows: Mark its equal subdivisions off on a straight line and then reverse the scale and note if the equal subdivisions coincide.

Limit of Accuracy of a Scale. The limit for accuracy in scaling should be, in commercial mechanical drawing, not more than one hundredth of an inch.

Distances from the Scale.

If any number of equal or unequal distances are to be divided off on a right line, they should always be marked off directly from the scale.

Straight Edge with Scale.

When several distances within the limit of the scale are laid off where there is no line on which to lay the scale, a straight-edge should be placed against the scale.

One Setting.

Consecutive distances within the limits of the scale should be laid off at one setting.

Protractor.

The protractor is legitimately used for laying off angles which cannot be gotten from the triangles.

Steel Protractor.

A steel protractor should be of first-class design and should have as little surface as possible to come in contact with the paper.

Other Protractors.

Cheap German-silver and celluloid protractors are not recommended.

Universal Drafting Machine.

The Universal Drafting-machine is a recent device which is advertised to combine all the functions of the T square, triangles, protractor, and scales. There is a great deal claimed for it and it is well recommended by practical men. It is perhaps too early yet to make favorable or adverse criticism of it, but after a time its true worth will be tested and rated.

Curved Ruler.

The curved ruler is often needed for delineating certain irregular lines, but it should not be used if circular arcs can be practically substituted.

Selection of Curve. A set of curves is often selected for a certain class of work; but one universal curved ruler will often meet most of the requirements. An average logarithmic spiral curve is recommended for general use.

Material. Curved rulers are usually made of such materials, with the exception of steel, as are found in triangles, and consequently they have the same advantages and disadvantages as regards convenience, etc.; hence, unquestionably, a transparent curved ruler is ultra-superior to any other.

Drawing Pencil.

The drawing-pencil has already been discussed with reference to the lead contained in it.

Form of Pencil. The form of the wood which encases the lead should not be circular in section.

Sharpen Points. It is a good plan to sharpen both ends to points not less than three eighths of an inch and not over one half of an inch long; one with a conical point and the other with a flat chisel point.

Use of Points.

The flat point should be used for drawing lines, and the conical point for free-hand work.

Flat Point.

When lines are drawn with the flat point of the pencil, it should be used for marking distances from the scale.

To Use Pencil.

The pencil, when in use, should have all of the available surface of the lead in contact with the straight-edge which guides it; and it should be held slightly inclined in the direction to which it is being drawn.

The pencil should be pressed lightly down and drawn from left to right and away from the manipulator.

Artist's Pencil.

The Artist's pencil with movable lead is a very desirable substitute for the ordinary drawing-pencil. Two of them should be procured for convenience, one with a conical-pointed and the other with a chisel-pointed lead in it.

Ruling Pen.

The ruling pen is about the most important instrument found among what are known as the case instruments.

The unskilled draftsman has been very often provoked into uttering undesirable epithets on account of poor execution; due, almost entirely, to poor material in the ruling-pen or to negligence in repairing it.

Selection and Care. It is of prime importance that the greatest care should be exercised in the selection of the pen; and it is of more importance to keep the pen in first-class working condition.

Test of Ruling Pen. The ruling-pen should have its blades made of the best tempered steel. It can be tested for the softness or hardness of the material by drawing a Swiss file lightly across its nibs.

Blade. The inside of the blades of the ruling-pen should be as little concave as possible.

Opening Device. One blade should be arranged with a properly designed hinge, or a device for opening the blade quickly and widely.

Hinged Ruling Pen. Many draftsmen oppose the hinged ruling-pen on the ground that the joint for the hinge impairs a certain rigidity which is essential when the pen is in use. It is undeniably true that a blade is more rigid when not jointed; but hinged ruling-pens have been designed, and there are some few on the market, which meet all the essential requirements of rigidity. It is vitally necessary that the hinged ruling-pen be designed with an effective device for taking up the wear at the joint.

To Clean Pen. A pen must be kept thoroughly clean; and a pen is not necessarily thoroughly cleaned by drawing a rag through it when the nibs are close together; but, if it is necessary, each nib should be rubbed off and smoothly polished.

Hence the convenience gained from a common-sense wide-opening pen.

Handle. The handle should be made of a material that is not easily broken. Bone or ivory handles are undesirable because they are easily broken; but an aluminum or ebony handle is very satisfactory, particularly the former.

Care of Nibs. The ends of the nibs must be kept in prime condition. Such a condition obtains when the ends of the nibs are perfect arcs whose radii are not over one thirty-second of an inch; are sharp as a pocket pen-knife, and both touch the paper when the pen is placed with its axis in a plane perpendicular to the plane of the paper.

Repair Nibs. To repair the ends of the nibs, proceed in the following order: first, clean the pen thoroughly; second, draw the nibs together until no light is seen between them; third, round off the ends with an oilstone into the shape of a circular arc with a small one thirty-second of an inch radius; fourth, spread the blades a little, and, with one blade held at an angle of about 30° and in contact with the plane surface of an oilstone, draw it forward and backward on the stone, and at the same time oscillate it, to keep the configuration on the back, until the edge is as sharp as a pocket pen-knife; fifth, rub lightly the inside surface of each nib with the plane surface of the oilstone to remove any possible burr.

To Set the Pen. The pen should always be set the proper width by the eye; which is done by holding it to the light or over a piece of white paper.

To Fill the Pen. The pen should ordinarily be filled not deeper than three sixteenths of an inch, unless an extra-wide line is to be drawn.

Refill the Pen. If the ink does not flow, do not ruin the pen by jabbing it into a piece of wood or paper, but start the flow by drawing it across the little finger or a wet sponge; then if the ink fails to flow, wipe out and refill the pen.

To Draw a Line. When a line is being drawn the pen should be held with its axis in a plane perpendicular to the plane of the paper, slightly inclined in the direction to which the pen is being drawn; and, with slight pressure on the pen, drawn from left to right and away from the person.

Ink on Outside of Pen. When a pen is in use, care should be taken that no ink is on the outside of the nibs and that the guiding straight-edge does not come in contact with the inked line. Carelessness and disregard of this advice will usually be followed by ink flowing under the instrument, and consequent provocation to the use of strong language.

Wipe Pen. Since most drawing-inks dry quickly and corrode steel, they must always be wiped thoroughly after use, even if it is only for a short interruption.

Care, Use, etc., of Instruments, Alteneder & Sons.

It behooves every draftsman to read that part of the catalogue of Theo. Alteneder & Sons, Philadelphia, Pa., which gives an admirable discussion of the ruling-pen and other instruments.

Pen for Widths of Lines.

A medium-size pen can be used to advantage for lines of all widths; and the belief held by many that a fine line and a coarse line are necessarily drawn with a small and large pen respectively is a fallacy.

Pen for Red Ink.

If red ink must be used, a separate pen should be reserved for it, since it is very corrosive.

Compass.

The best compass of to-day has its main legs, lengthening-bar, needle-point leg, and pencil-leg made of a fine, uniform grade of German silver. They should be sufficiently rigid to prevent any bending when ordinarily handled, and not easily broken or cracked when accidentally dropped.

Joints.

All joints should have large, dustless, and non-bruisable bearing surfaces ; and simple and well-designed devices for taking up wear.

Means for Holding Detachable Parts.

The compass should have simple and effective means for holding detachable parts. Undoubtedly the round shank and corresponding split socket with its clamping-screw is the best design obtainable for connecting and discon-

necting the detachable parts to the compass-legs.

Handle. The cylindrical handle, on the yoke which straddles the joint at the top of the legs, is indispensable for facilitating the manipulation of the compass.

Flexible Joints. The pen, pencil, and needle-point legs should be provided with flexible joints, designed according to the specifications given for corresponding joints in the compass-legs; and also, the joints should be as near to the working points as practicable.

Pen of Compass. The pen should be designed and cared for in the same manner as specified above for the ruling-pen.

Pencil of Compass. The pencil should be of a material described above in "Substances Applied, etc.," and of nothing softer than a HHHHHH grade. It should be so sharpened that the point has a very flat elliptical section.

Needle Point. The needle-points should be made of the best tempered steel with one end conical, and the other end with a very short, sharp, and fine point, terminated by a square shoulder.

Device for Holding Needle Point. The needle-point and lead should be a good fit in a split socket, and held in place with a clamping-screw. The device for securing a needle-point by the point of a screw should be shunned.

A needle-point should not be screwed into the socket.

Use of Needle Point. The shoulder end of the needle-point should always be used when drawing circular arcs, and should be adjusted so that both the shoulder and pencil- or pen-points touch the drawing when they are perpendicular to the plane of the paper.

Care of Needle Point. The needle-point should be occasionally ground on the oilstone until it is sharp enough to enter the drawing-paper, when a pressure due solely to the weight of the compass is applied.

Lubricate Screws. If a screw in the compass or bow instruments works hard or becomes rusty, a little graphite rubbed off the drawing-pencil will lubricate it.

Distance Taken by Compass. A distance should always be taken by the compass directly from the scale, which is acplished by holding the compass level with the surface of the scale, and applying the compass so that the shoulder of the needle-point and the end of the pencil- or pen-point just touch the edge of the scale.

Drawing a Large Circle. When a large circle is being drawn with the lengthening-bar inserted, the compass should *never* be steadied by taking hold of one of the legs, but it should be gripped, as before, by the cylindrical handle at the yoke, and very slightly inclined in the direction to which the compass is moving, which direction should always be right-handed or clockwise.

Beam Compass.

The beam-compass is used for striking large circular arcs.

Materials for Trammel Points. The trammel-points and their attachments should be made of materials used for similar purposes in the compass, and cared for after the same manner as prescribed for the regular compass.

Attachments. The needle-point leg should be fixed, but the pen- and pencil-legs should be interchangeable; and the compass should be provided with a micrometer-adjustment attachment.

Beam. The beam should be designed for stiffness and to permit of smooth running of the trammels along its length.

Fastening Trammels. The trammels should be provided with a strong and rigid fastening device.

Tubular Beam. The metal tubular beam with a split socket on the trammels for binding is recommended.

Spring Wheel Attachment. When an arc of long radius is drawn a spring wheel attachment should be used close up to the pencil- or pen-point.

Dividers.

The dividers should be made of materials which are used for similar purposes in the compass, and should be cared for after the same manner as prescribed for the regular compass.

Legs. One leg should be without a joint, and the other leg should be provided with only a hair-spring adjustment.

Needle Points. The needle-points should be conical.

Laying off an Exact Length. If an exact length is to be laid off with the dividers, a large multiple of that length should be laid off first directly with the scale on a right line, and then exactly sub-divided into the desired exact length by the dividers.

Bow Instruments.

The bow-instruments consist of the spacers, pencil, and pen. They should be made of the best tempered steel, with a metal handle and a central adjusting-screw.

Use and Care of Bow Instruments. The spacers, pencil, and pen are used and cared for in the same manner as prescribed for the dividers and compass, but they are distinctly designed for short lines and arcs of short radii.

"Drop" Bow Pen. The so-called "self-adjusting needle-point" or "drop" bow-pen has the particular advantage of requiring no adjustment of a needle-point to suit the length of the pen or pencil; but the needle-point end should be made with a shoulder, and not conical as is usually done.

Pricker Point.

The pricker-point is used for marking off distances more accurately from the scale than can be done with the drawing-pencil.

To Make a Pricker Point.

A fine sewing-needle, with the eye end firmly driven into a non-cylindrical handle, makes a desirable pricker-point.

Pricker Point in Pen Handle.

A ruling-pen with the pricker-point inserted in the handle can be purchased for a few cents extra.

Case for Instruments.

A case should be procured for the ruling-pen, compass and attachments, dividers, and bow instruments.

Pocket Case.

The folding pocket-case is undoubtedly the most convenient, but a good case can be made of chamois-skin by sewing pockets into it; and the chamois-skin would be incidentally useful for cleaning the instruments, which should be done every time the instruments are used and laid aside.

Writing Pen and Staff.

The writing-pen and staff are essential and important in a draftsman's outfit, for lettering, etc.

Bulging End.

The pen-staff should have a bulging cork end where the pen is inserted, and should be gripped close to the pen when it is used for printing.

Coarse Pen.

The pen should be comparatively coarse with a ball point for holding ink.

Fine Pens.

"Crow-quill" and "Falcon" pens should usually be rarities in a commercial mechanical draftsman's outfit.

Selection of Pens.

Care and common sense must be exercised in the selection of the writing-pen for the different grades of work.

Pressure on Pen.

No more pressure should be applied to the writing-pen than to the ruling-pen; and the erroneous belief that a fine flexible point when worked under pressure is the proper pen, is as puerile as wetting the pencil-point in the mouth.

Pen Wiper.

A good wiping-rag is an essential. It should be free from lint; and a good one is usually found wrapped around the bottle of the prepared drawing-ink.

Tracing-cloth when soaked free from the glazing makes a very desirable wiper.

Pencil Pointer.

A good pencil-pointer is found in a steel file or a sandpaper pad.

Mechanical Pointers.

There are several good devices for sharpening pencils mechanically, which should be selected with scrutinizing care and judgment.

A jack-knife should *never* be used for finishing the point of a drawing-pencil.

Pencil Eraser.

A pencil-eraser should be of open rubber and not the usual velvet type. It should clean the surface of a drawing with very little rubbing and leave it perfectly smooth.

Sponge Rubber. A sponge rubber is found convenient for cleaning the surface of a drawing without obliterating the pencil-lines.

Bread Crumb. Fine crumbs from stale bread effectually clean a drawing.

Ink Eraser.

An ink-eraser should be made of a fine abrasive substance which is quick-cutting and non-heating; it should leave the surface of the drawing perfectly smooth.

Pumice Stone. Fine pulverized pumice-stone will very effectually take out ink lines when rubbed on a drawing.

Steel Eraser. A steel eraser is indispensable in the hands of a skilful draftsman; and a pocket-knife is no proper substitute for it. It should be made of the best-tempered steel, have a wooden handle, and its edge must be kept keen.

When a steel eraser is used the ink should be just taken off the drawing and no more.

To Erase Ink. It is much better for the unskilled person to take off only a part of the ink with the steel eraser and finish with the ink-eraser.

Erase Thoroughly. When lines are erased from a tracing they should be thoroughly rubbed off, to avoid vagueness on the print as to what was intended on the drawing.

Eraser Shield.

An eraser-shield is sometimes found useful where only a particular and very small part of the drawing is to be rubbed.

Eraser Shield of Tin, etc.

An eraser-shield can be made by slitting a piece of sheet tin, brass, or celluloid.

Drawing Paper Shield.

The straight edge of a piece of brown drawing-paper also answers very well for a shield.

Oilstone.

An Arkansas knife-oilstone should always be found in a draftsman's kit, and should be used when necessary. It is always an index of a good workman when his tools are sharp and in prime condition.

Tacks.

The tacks for holding down drawings should have small heads.

Copper Tacks.

The 1-ounce copper tack is recommended; but the 1-ounce iron carpet-tack is an eternal nuisance. Its head breaks easily and leaves the point in the drawing-board to be picked out before the board can be planed off, as is often done when it is repaired.

Thumb Tacks.

Thumb-tacks should have a small flat head rounded on the edge and a sharp point.

Tack Lifter.

The tack-lifter is a convenience and not a luxury. It will doubtless preserve the original shape of the blade-point of the pocket-knife, which is so often resorted to as a tack-lifter. A piece of $\frac{1}{4}''$ or $\frac{5}{16}''$ steel wire, three or four inches long, with one end flattened to an edge and bent into a claw shape, will serve as a tack-lifter.

Machinist Scale and Caliper.

A six-inch machinist scale and a six-inch reversible inside and outside caliper are often found convenient in taking measurements when a draftsman is required to sketch a piece of mechanism that is already made.

Folding Rule.

A six-foot folding rule is found very useful in many ways. It is often a suitable accompaniment to the caliper for getting the approximate dimensions of a piece of mechanism which is being sketched.

LIST OF DRAWING INSTRUMENTS.

A list of drawing-instruments is given below which every machine draftsman should have for a first-class and fairly complete equipment:

One 24″ and one 42″ mahogany T square, head fixed with five screws, ebony-lined head and blade, and with working edge of blade beveled.

A 10″–30°×60° transparent triangle.

A 7″–45° transparent triangle.

Three 12″ nickel-plated sheet-steel Brown & Sharpe scales with graduations conveniently distributed on them as follows: $\frac{1}{8}$″, $\frac{1}{4}$″, $\frac{3}{8}$″, $\frac{3}{4}$″, $\frac{1}{2}$″, 1″, $1\frac{1}{2}$″, and 3″ to the foot, $\frac{1}{16}$″ and $\frac{1}{100}$″.

A 5″ first-quality and first-class designed, hinged or quick-opening ruling-pen, with inserted pricker-point in handle.

A $5\frac{1}{2}$″ compass of the first-quality with jointed and fixed leg for needle-point, detachable jointed pencil- and pen-legs, and lengthening bar.

Bow-pen, pencil and spacers, with central adjusting-screw, for scribing not over $1\frac{1}{2}$″.

A pair of 5″ dividers with hair-spring adjustment.

A pocket-case or chamois-skin with pockets for protecting the usual case instruments.

A good nickel-plated steel protractor.

A good beam-compass with trammel-points, and with three beams of two-feet, four-feet, and six-feet lengths.

One HHHH and one HHHHHH Hardmuth Koh-i-noor grade drawing-pencil.

A set of Hardmuth's Koh-i-noor grade HHHHHH lead for compass.

A good pencil-pointer.

A good steel eraser.

An ink-eraser—Faber's.

A pencil-eraser—Tower's Multiplex.

An eraser-shield.

A six-foot folding rule.

A package of 1-ounce copper tacks.

An Arkansas knife-oilstone.

A pen-staff and writing-pens.

A bottle of black water-proof drawing-ink.

PART II.

COMMERCIAL MECHANICAL DRAWINGS.

Before defining a commercial mechanical drawing it may be well to anticipate the confusion which may arise as to the technical meaning of the phrase "Mechanical Drawing," since it has two distinct meanings. The phrase "Mechanical Drawing" may be interpreted as any drawing in general that is not made free-hand; or, as a drawing that particularly pertains and is incident to machine construction. The latter interpretation is the one used in the definition given in the succeeding paragraph.

A Commercial Mechanical Drawing is fully defined when such conventions are present as to enable the manufacturer or builder in mechanical lines to erect his buildings, to select and arrange his equipment for most economical production, or to produce, by means of the drawing, and with the greatest facility, that which has utility and a commercial value.

Commercial Mechanical Drawings can be divided into three general types which will be

termed: General Plans, Machine Drawings, and Patent Office Drawings.

General Plans would include such drawings as: Layout Drawings, Foundation Drawings, Piping Drawings, etc.

Machine Drawings would include: Working Sketches, Scheming Sheets, Detail Drawings, Assembly Drawings, and Diagram Drawings of Machines.

Patent Office Drawings are in a class by themselves, and are essentially such drawings as are required by the United States Patent Office when a claim for a patent on a mechanical invention is presented.

GENERAL PLANS.

Drawing plans of buildings intended for mechanical purposes are often made with nothing more on them than a section of the walls, with the doors, windows, and supporting piers for columns located, and sometimes a very general arrangement of the inside equipment shown in part or the whole.

Layout Drawing.

Fig. 1. A layout drawing is often a plan of a floor of a building with the positions of different parts of the equipment located to scale. It is also, sometimes, a preliminary drawing of a part or a whole of a machine, and serves the same

purpose as the scheming-sheet which is defined below. The former sense, however, will be accepted in this Manual.

Locating Machines. In locáting a large number of machines or other equipment in a plant, they should be drawn first to scale on a sheet of fairly stiff drawing-paper, cut out, and then moved on the proposed drawing until they are satisfactorily arranged; after which they can be drawn to scale.

Piping Drawing.

A piping drawing shows the arrangement of the piping separately from other equipment in the building.

Several Kinds of Piping. If there are several kinds of piping, as steam-pipes, hydraulic-pressure pipes, water-service pipes, etc., and they are to interpass each other, they should be all drawn on one sheet to show their relation, and then each class by itself can be drawn on a separate sheet for the use of the piper.

Simple Lines. Fig. 2. In laying out piping drawings, no attempt must be made to draw elaborate views of the fittings, but simple and conventional lines should represent them. All valves, unions, tees, and important connections must be plainly indicated.

Do Not Crowd Pipes. Do not locate pipes too closely together, but leave a little leeway for the piper.

Pipes along Walls, etc.

Always show an outline of the walls, machines, etc., along which the pipes run and with which they are connected.

Foundation Drawings.

Fig. 3.

Foundation drawings should show the nature of the foundation upon which a machine or building stands, whether it is in wood, stone, concrete, or brick; also, the position of the anchor-bolts, with their attached caps, anchor-plates, washers, and nuts, and also the main outlines of the machines which set on them.

Templet Drawing.

A templet drawing usually shows a templet made of boards which are nailed together, and with holes bored in them, which have the relative dimensions between them that are required for locating the anchor-bolts in the foundation.

Brick Work. Fig. 3.

If brickwork is shown in a foundation, a continuous right line and not the corbeling should show the outline of the foundation.

Boiler Settings.

Drawings of boiler-settings would be included under the head of foundation drawings.

MACHINE DRAWINGS.

When a new machine or any of its parts has been conceived, the next step is to develop it on drawings.

Naturally, the most simple drawings will be made first, and will be followed in logical sequence by more complete drawings.

A machine drawing must be made simple, clear, and direct. Any attempt to imitate the product of the camera, or to display impractical rudimentary knowledge, is foreign to the practice in the United States at present, and must be eliminated in order to harmonize with the existing state of affairs.

Descriptive Geometry, which is the foundation on which all mechanical drawing (used in a general sense) has been built, should be, practically, theoretical drawing applied; and, as such, it will mean a radical revision in the text as found within the covers of the current textbooks, which are used, and fully intended, as a *vorspiel* to all mechanical drawing, whether or not such drawings are along the lines of stereotomy, architecture, or mechanical drawing.

Thus it is, that the draftsman must apply his knowledge of Descriptive Geometry in such a manner as to harmonize with methods and rules of procedure current in the modern practice of making machine drawings.

To make a machine drawing properly and most intelligently, the draftsman has no other recourse than to be a thorough mechanic himself; which implies a working knowledge of pattern-making, molding, forging, and machining.

SKETCHES.

Preliminary free-hand sketches should be made with a soft black pencil, and only the essential outlines of the proposed piece are needed.

Save Sketches.

Several sketches may be required before one is satisfactory; and all sketches made should invariably be saved for possible future reference.

Several Sketches of Same Thing.

It is a rule frequently followed by designers and inventors to make several sketches of the same thing; and it often happens that they return to and use the first sketch made.

Cross Section Paper for Sketching.

Cross-section paper is invaluable for sketching, as proportion is secured without the use of the scale.

Copying Pencil Sketches.

Copying-pencil sketches are frequently made to serve the purpose of a small drawing or blueprint. They should be made with a copying-pencil on checked paper, and duplicated by means of a damp cloth and a letter-press.

Scheming Sheet.

A scheming sheet is made up of the accepted free-hand sketches drawn to scale and with somewhat more detail shown.

They should be drawn in with a HHH or HHHH grade drawing-pencil on drawing-paper, and no elaboration to completeness is usually needed.

Detail Drawings.

Detail drawings are undoubtedly the most important, and surely the most extensively used, drawings.

The details in the execution of a properly made detail drawing are a complete history and exposition of the art of machine drawing. Therefore what has been written in the paragraph directly under the heading "Machine Drawings" distinctly applies to detail drawings and must be strictly adhered to.

The Workman's Drawing.

After the parts on the scheming sheet have been made in a general drawing, they are then completely detailed for the various departments of the shop. Consequently, a detailed drawing is the workman's drawing; and, as such, it is his official order for doing the assigned work. He should be held responsible only for failure to work to the figures and the Anglo-Saxon notes on the drawings.

Projections, etc., Secondary.

The projections and conventions are secondary and only serve as illustrations to interpret what the figures and notes stand for.

Number of Parts Detailed.

The number of parts of a machine detailed on a drawing may depend on the methods used in doing the work, or upon the number of men who are to work from the drawing, or upon both.

Detail drawings are usually penciled on light-brown drawing-paper and traced on tracing-

cloth, or penciled and inked on bond paper and printed on blue-print paper in the order given.

For convenience of analysis the considerations, methods, and technic involved in the complete execution of a detail drawing will be discussed under separate headings.

Types of Detail Drawings.

The number of parts of a machine detailed on a drawing should be according to the nature of the work and the methods of doing it. If a shop is manufacturing machines in lots, where six or more are built exactly alike and at the same time, not so many parts would be detailed on one drawing, and the work would be distributed among a larger number of men.

Individual Drawings.

It is the practice with some firms, and the growing tendency with others, to make individual or separate drawings of a great many of the parts.

Casting and Forging Details Separate.

It has been the custom of some firms to place the casting details and forging details on separate drawings; and that scheme would be particularly advantageous to firms which build.

Assembly Detail Drawing. Fig. 40.

When a single new machine, or a section of it, is built for the first time, it is often advisable to show the parts in partial assembly and fully detailed on the drawing. Such an arrangement assists the mechanic to make his allow-

ance for proper fits and adjustments. This type of drawing might serve as an assembly or general drawing, and, perhaps, it is more properly called an assembly detail drawing.

Sizes of Drawings.

Fig. 5.

The size of the detail drawing is dependent on the type of drawing, the size or sizes of the part or parts detailed, and the scale to which they are drawn.

The following sizes are good average ones, as they can be cut very economically from the commercial widths of drawing-paper: 6×9, 9×12, 12×18, 18×24, 24×36, 36×48, and 48×72.

Border Lines.

Fig. 5.

Border lines are of no material assistance to the mechanic or to any one else, except possibly to the draftsman, who may comfort himself with a doubtful fact that the appearance of the drawing is enhanced.

Omitting Border Lines.

The writer believes it to be the growing tendency to leave off all border lines; but when they are used, they should not be over one thirty-second of an inch wide and have no fancy or elaborate corners.

Border Lines One Half Inch from Edge.

The border line should be placed one half inch from the edges of the sheet; it is the first thing to be drawn in a pencil drawing, and the last thing in an inked drawing.

Match Lines.

Fig. 4.

Short lines drawn with the T-square on each side of the drawing are convenient for resetting a drawing after it has been removed from or accidentally shifted on the drawing-board.

Titles.

Fig. 5.

A title is an essential part of any drawing, and a particular and invariable place on the drawing must always be provided for it.

Place for Title.

A place at the lower right-hand corner of the drawing should be blocked out for the title, and directly after the match-lines are drawn.

Parts of Title. Fig. 5.

The title should comprehend: first, the type of drawing, as a sketch, assembly, or detail; second, the name of the machine drawn, or the part thereof, or both; third, the name of the firm which builds the machine; fourth, the address of the firm; fifth, the scale or scales used on the drawing; sixth, the name or initials of the person or persons who are responsible for the finished drawing,—which includes every one, from the penciling draftsman, through the tracer and checker, to the approving engineer,—and also the date on which the drawing is finished.

Additional Parts of Title.

In addition to the above there is occasionally placed along with the title the shop order number, the sheet number, the number of the drawing in the case where the drawings are stored,

and the lot number—provided the machine is manufactured in large lots.

Size of Letters. Fig. 4.

The words indicating the name of the machine must be in larger letters than the rest, since it should be the first or chief thing seen in a title.

Fig. 4.

The words indicating the type of drawing, the name of the firm, the address, and the scale should be composed of letters of the same size, but they must be smaller than the letters in the words which indicate the name of the machine.

Scale Terms. Fig. 4.

The words used to indicate the relative sizes to the true size of the objects as drawn should be expressed, preferably, in the terms of a scale; as, so many inches to the foot, or so many millimeters to the meter; or, if not, a proportionate size should be given; as, full size, one-half size, etc., etc.

Size of Letters for Name. Fig 4.

The date and the names or initials of the persons responsible for the drawing should be in very small letters.

Symmetry of Title. Fig. 4.

All lines in the title must be arranged symmetrically with reference to a center line.

Stamp for Title.

The title is occasionally put in with a stamp,* which usually stamps the tracing in red ink; after which it is filled in with black drawing-

*The title or border lines, or both, are sometimes printed on in black with an ordinary printing-press before the drawing is begun.

ink. The black drawing-ink should be applied while the red ink is still wet.

Place for Size of Sheet and Serial Number. Fig. 5.

In the lower left-hand corner there should be placed a letter and number which correspond with the size of sheet and serial number of the drawing respectively; as, for example, A–2 will indicate that the sheet is 36×48 and is the second consecutive drawing that has been made.

Sizes of Sheets.

The letters which should be used, with the corresponding sizes of sheets, are as follows: A, 36×48; B, 24×36; C, 18×24; D, 12×18; E, 9×12; and F, 6×9.

Bill of Material.

Place for Bill of Material. Fig. 5.

Every detail drawing should have a bill of material which should be placed directly above the title; and it is a good plan to block out a space for it immediately after the title has been allowed for.

Every Piece on Bill of Material.

Every piece in a machine or its parts, or in any structure, should be accounted for on the bill of material, so that any clerk in the office can order from it independently of anything else.

Columns of Bill of Material. Fig. 5.

In the table of the bill of material, the first column should contain an identifying mark which is exactly the same as the one placed on the view of the piece as shown on the drawing, and may be a letter or a number. The second column should contain the name of the piece.

The third column should contain the number wanted of the same piece for one machine, or for one composite structure of any sort. The fourth column should contain the name of the material of which the piece is made. And the last column should contain any further necessary description of the piece, which may be, for example, the pattern number, the dimensions of the rough stock from which it is made, the method of casting, etc.; and, in fact, the last column should provide for any description of the piece not found in the first four columns and which would be essential for completeness in the order for the stock.

Common Terms. The name of the piece in the bill of material should be a common shop-term used by the mechanics; and if there is none, a simple and suggestive one must be used.

Pattern Number. Every piece that is cast from a pattern should be given a pattern number in the column under the head of "Remarks."

Views.

The number of views is determined by that judgment which serves common sense.

Only Necessary Views. All the views necessary and no more should be drawn.

Most Comprehensive Views. The selection of a view or views which shows the piece in the most comprehensive manner should always be made.

Simple Pieces. Fig. 5.

In simple and symmetrical pieces, as a round shaft, bolt and nut, plain gears, etc., one view is sufficient.

Symmetrical Pieces. Fig. 14.

If an object is symmetrical in every respect and it is required to show some little irregularity, it is sometimes only necessary to show a part of a view.

Crooked Pieces. Fig. 15.

In a very crooked piece several views may be quite necessary.

Sectional View. Fig. 5, "D."

A sectional view is often clearer than an outside view to the mechanic who works from the drawing, but it should not be made unless clearness obtains.

Combined Outside and Sectional View. Fig. 6.

If an object is symmetrical, it is often better shown by making a combined outside and sectional view; usually making the division at the center line.

Develop Plates and Cams. Fig. 6.

All bent and unusual-shaped plates must have their surfaces developed, if it is necessary, to show proper spacing of rivets, bolt-holes, outline of cams, etc.

Full Size Section of Piece on Reduced Scale. Fig. 7.

It is sometimes essential that an object which is drawn on reduced scale should have some important section of it shown full size.

One View for Rights and Lefts.

When there are two pieces that are exactly alike in every respect except that they are of opposite hands, one should be drawn in all of its views, and a note should be added to indicate that they are *rights* and *lefts*.

Concentric Circles. Fig. 38.

In any view where there are a number of concentric circles, show only a few; as they are practically worthless for conveying any idea, and only useful to fill space.

Flat Surface on Body of Screw, etc. Fig. 16.

A flat surface on the body of a screw, stud, or shaft is occasionally indicated, when there is only one view, by a rectangle with its intersecting diagonals.

Bearings on a Round Shaft. Fig. 17.

Rectangles, with their intersecting diagonals, are often used for indicating the bearings on a round shaft, as a line-shaft, crank-shaft, etc.

Knurled Piece. Fig. 5, "M."

A knurled or milled piece should be shown conventionally in a view.

Square Bolt Heads, etc.

In the side views of square bolt-heads and nuts, show only one side.

Hexagonal Bolt Heads, etc. Fig. 5, "C." Fig. 40.

In the side views of hexagonal bolt-heads and nuts, show three sides.

Distance of Holes on a Circle from the Axis. Fig. 5, "H."

In a sectional side view of a cylindrical piece, if there is one hole or more in it parallel to their axis, they should be shown at their true scale distance from the center as measured each side of the center line.

Washers and Collars Attached. Fig. 5, "G."

Washers and collars should generally be shown in section on the piece to which they belong.

Keys Attached. Fig. 5, "C."

Keys should be shown in the piece into which they are driven.

Side Views of Conventional Thd's. Fig. 18.

The side view of a Seller's V-thread, pipe-thread, square-thread, bastard or acme stand-

ard-thread, knuckle-thread, buttress-thread, and wood-screw thread are conventionally shown by the figures in their respective order.

Threaded Piece Sectioned. Fig. 19.

If a threaded piece is sectioned nothing but the V's should represent the thread.

End Views of Screws, etc. Fig. 20.

The end views of a screw and tapped hole are conventionally shown by the figures in their respective order.

Filister Head Screw. Fig. 21.

A filister-head screw should show, in all views of the end, its slot making an angle of 45° with the horizontal; and the slot should show, in the side views, a true projection of the end views.

Regular Pulley. Fig. 10.

A regular pulley is shown by the conventions in the figure.

Fig. 5, "D." Fig. 8. Fig. 9.

Spur-, bevel-, and worm-gears are shown detailed as by the conventions in the figure.

Cast Gears.

Cast gears made from a pattern should have, in addition to an ordinary view, one tooth completely detailed and the number of teeth specified.

Arrangement of Views. Fig. 5.

The arrangement of views on the drawing demands, for the sake of clearness, system, and convenience; first, that they should not be crowded; second, that all views of the same piece should not be separated any further than necessary to show outside dimensions and notes clearly; third, that all views of different pieces be sufficiently separated to prevent any confu-

sion as to their proper relations to views of other pieces; fourth, as far as possible, all pieces of a machine must be shown on the drawing in their natural relative positions in the machine and to each other.

Section Views at One Side. Fig. 38.

Sectional views can be placed, if convenience demands it, at any place on the sheet provided they are properly noted.

Arranging Views of Pieces on Sheets.

To cover the drawing sheet properly with views, it is sometimes convenient to approximately pre-arrange the location of all views by enclosing them in a rectangle which is sufficiently large to include the outside dimensions and notes to the view. At other times it is not necessary to do much planning, but commence at the upper left-hand corner and work across and down the sheet. This order of working across the sheet should always be followed.

Third Angle Projection. Fig. 5.

The relation of views to each other must always be what is technically called third-angle projection; which, interpreted, means: that when there is a definite and natural top to an object, its projection should be the top view, which is often called the plan; that the views of the elevation should be shown below the top view; and that, in addition, every projection must be shown as the near side of the adjacent view from which it is projected.

Sectional View. Fig. 5.

In a sectional view the portion of the object

which is cut away and nearest the view is removed, and what is left is shown in the sectional view.

Lines of Projection.

Fig. 11.

A visible edge of a solid should be represented by a full line, clean-cut, comparatively wide, to make them stand out in a bold effect, and of uniform width throughout their length.

Round Corner. Fig. 10.

Where a corner is not sharp but rounded, it is admissible by convention to represent it in all views, if any clearness is gained thereby.*

Always show filleted or rounded corners when finished adjoining surfaces do not forbid.

To Draw a Hexagonal Figure.

All lines bounding a hexagonal figure should be drawn in tangent to a circle whose diameter is equal to the distance between parallel sides of the hexagon, and by means of the triangles and T square.

Distance Across Flats and Corners of Hexagonal Bolt Heads.

When the three faces of a standard hexagonal bolt or nut are shown, make the distance between the outside lines equal to twice the diameter of the body of the screw, and the distance between the inside lines a trifle less than the diameter of the body of the screw.

Curves of Intersection. Fig. 10.

Curves of intersection should be put in as circular arcs when possible.*

Ellipse. Fig. 22.

An ellipse in projection which is not very flat may be shown, by convention, by a circle.

* See curve of intersection of pulley-arm with bead on rim.

Chamfers on Bolts, etc.

Make the chamfers on bolts, studs, shafts, etc., 45° lines.

Oil Holes and Channels.

Oil-holes and channels are usually not shown, unless they are to be made in an unusual manner.

Spacing of V Thread Lines. Fig. 5, "C."

The spacing of V-thread lines, and their pitch, may not be absolutely exact; but a fine thread naturally has its lines close together and has less pitch than a coarse thread.

Spacing of Thread Lines Except V Threads.

The spacing of all thread lines, except V-threads, should be approximately close and always done by marking off distances directly from the scale.

Sectioned Nuts. Fig. 19.

Remember that nuts, when sectioned, theoretically show the pitch of the threads in reverse order to those on the screw which fits it.

Long Screw. Fig. 5, "F."

When a screw is of considerable length four or five threads should be drawn at the ends only, leaving the intervening length blank.

Invisible Edge. Fig. 11.

An invisible edge of a solid should be represented by a broken line which is clean-cut and composed of comparatively short dashes of equal lengths. The dashes should be drawn as close together as possible, and not quite so wide as the visible lines of projection.

Invisible Lines. Fig. 5.

An invisible line, composed of more than one dash, should always begin and end on the terminating lines which include it.

Short Invisible Lines.
Fig. 23.

If an invisible line is shown by one dash only, it should not begin or end at the terminating lines, but a short space should be allowed between the dash and terminating lines.

Adjacent Part Line.
Fig. 3.

An adjacent-part line is a line in another object which is adjacent to the one regularly shown on the drawing, and simply serves the purpose of indicating, for some particular reason, what is attached to the piece shown on the drawing. Therefore it should be a main outline, of sufficient length to indicate what is attached. It should be a fine, broken, clean-cut line composed of alternating dashes of one eighth of an inch and three eighths of an inch lengths respectively, drawn as close together as possible.

Broken Edges.
Fig. 11.

A broken line represents the visible and invisible edges of the part of a solid of a structure that is broken off. The width of this line should correspond to the width of the projection line adjacent which represents the edge of a surface.

Alternate Position Lines.
Fig. 11.
Fig. 24.

An alternate position line is used for representing a limiting or important position of a moving part, other than is shown regularly on the drawing. An alternate position is sometimes represented by drawing the bare outlines of the object, or by a center line. If the bare outlines are drawn, they should be fine, broken,

clean-cut lines, composed of alternating dashes of one-eighth of an inch and three-eighths of an inch lengths respectively, drawn as close together as possible.

Sectioning.

Fig. 7.
Fig. 38.

Where there is a section view, the trace of the cutting plane shown on the view of the object that is cut should be represented by a fine line whose character is that of a center line. The line is also to be notated at each end, and the corresponding notation must be suitably placed and referred to under that view which shows the section.

Section Lines.
Fig. 5.

Section-lines, which are sometimes called hatch-lines, are oblique parallel lines at equal distances from each other. They are used to represent a surface which has been cut.

Angles of Hatch Lines.
Fig. 5.

Usually hatch-lines make an angle of 45° with the horizontal; but it is not criminal, but even sometimes desirable, to use 30° and 60° lines if the conditions warrant it.

Spacing of Section Lines.
Fig. 5.

The spacing of section-lines should be determined by the area of the sectioned surface on the drawing and the kind of material which is cut. But section-lines should not be over three thirty-seconds of an inch apart; and softer material should be shown with section-lines further apart than those that show harder material.

Sectioning Adjacent Pieces. Fig. 8.

Two pieces which are assembled and shown in section must be hatched with lines in reverse order.

Hatching Penciled Drawing.

All hatching should be done free-hand on penciled drawings which are to be inked.

Sectioning Large Area. Fig. 25.

When the surface covers a large area the hatch-lines should be short and placed along the edges only.

Materials Cut. Fig. 12.

There are conventional lines to represent the different materials that are cut; but they are often unintelligible to the mechanic, and their relegation to oblivion is strongly recommended.

Section Shown by Soft Pencil Shading.

A soft drawing- or crayon-pencil is often rubbed on the surface of the drawing to represent the section, but a blue crayon-pencil should never be used for the purpose when a print is to be taken from it.

Thin Pieces. Fig. 10.

A rib, an arm of a pulley, or any comparatively thin piece should not be shown in section when the cutting plane is taken parallel to its largest bounding surfaces.

Solid Round Piece. Fig. 40.

A solid round piece should not be shown in section when a cutting plane is taken through its axis.

Turned Section. Fig. 10.

A turned section placed on a view is convenient, more direct, and often clearer than when placed off at one side.

Key Way.
Fig. 5, "E."
Fig. 10.

A keyway in a hole should not, as a rule, be sectioned, but should be shown by an invisible line.

Broken Pieces.
Fig. 13.

Pieces that are broken at the ends are shown conventionally in the figures.

Center Lines.

Fig. 5.

A center line is used to indicate symmetry, and any configuration which has a natural axis or axes, has a center line or lines to represent it or them. A circle, for instance, should have two center lines at right angles to each other.

Circles along a Circumference.
Fig. 5, "H."
Fig. 40.

When circles are evenly spaced along a circumference on the surface of a disc, as bolt-circles on a flange, a circular arc and radial lines passing through the bolt-hole centers, are used as the center lines.

Character of Center Line.
Fig. 11.

A center line should be a fine, broken, clean-cut line, composed of alternating dashes of one-eighth of an inch and three-eighths of an inch lengths respectively, evenly spaced and not too close together. A short center line may consist of one dash.

Penciled Center Lines.

Penciled center lines that are to be inked or traced over should be a full line.

Lines having Precedence over Center Lines.

Lines of projection, which show visible and invisible lines of an object, and surface shade-lines, have precedence over center lines in case there is coincidence.

Dimensions.

There is nothing on the whole drawing so important as the dimensions.

A dimension-line is used for indicating a dimension between certain limits, and it is broken at some convenient place between its limits (preferably midway) to allow for the dimension.

Character of Dimension Lines. Fig. 11.

The character of a dimension-line should be a fine, broken, clean-cut line, composed of equal dashes, equally spaced from each other.

Arrow Heads. Fig. 11.

All dimension-lines, excepting those representing radii of circular arcs, are terminated by arrow-heads at both ends.

Radius Dimension.

A dimension-line which indicates a radius is terminated by an arrow-head at the arc only; and if there are no intersecting center lines at the center from which the arc is struck, a small cross should indicate it. *Rad.* should be placed after the dimension.

Character of Arrow Heads. Fig. 5, "K."

The arrow-head should make a small acute angle with the dimension-line, and should be made in short arcs with the same writing-pen which is used for the figures and letters on the drawing.

Fig. 5, "K."

All dimensions should be given with reference to main lines or center lines or both.

Position of Dimension Line.

The position of the dimension-line is determined by judgment. It should be placed on

that view which shows the most, and in such a manner as to indicate most clearly and directly what the dimension between the extremities of the line stands for.

Distribution of Dimensions. Fig. 5, "K."

It is well to distribute the dimensions of a piece over its views, if clearness is gained by so doing.

Dimensions on One View. Fig. 5, "H."

Dimensions of any particular configuration of a view, as that of a circle, rib, rectangular surface, etc., should be shown on one view if possible, and *not* on several views.

Dimensions on the View Itself.

A dimension is more clear and direct when placed on the view itself, provided it does not cause a confusion of lines so as to impair clearness; and also provided there is sufficient space, without crowding, for the figures between.

Dimensions off the View. Fig. 11.

The dimensions, however, may be placed off the view, and a curved witness-line drawn from it to the usual place for the figures at the dimension-line.

Do not Crowd Dimension Lines.

Dimension-lines should not be placed so close to other lines as to impair clearness.

Groups of Parallel Dimension Lines. Fig. 8.

When dimensions are grouped in parallel lines the shortest dimension is inside, and the others are graded to the longest dimension on the outside.

Arrow Heads Outside of Lines. Fig. 26.

If one or the two ends of a dimension-line terminate in the vicinity of two parallel lines

which are close together, and confusion is caused thereby as to which one of the parallel lines limits the dimension-line; and if the dimension is limited by the outside line or lines, additional short dimension-lines with arrow-heads should be placed in a line with the dimension-line, outside of the line or lines and with their arrow-heads just touching the limiting line.

Fig. 5, "L."

A short dimension can be shown by placing the dimension-lines with their arrow-heads on the outside of the limiting-lines, and the dimension can be placed inside.

Whole of Dimension Line Not Shown. Fig. 27.

If one end of a dimension-line cannot be shown joining the limiting line, the usual full dimension is given, and the dimension should be placed as usual between the lines.

Sub Dimensions. Fig. 28.

A line of sub-dimensions should always commence at the finished surface; and if there is an unfinished surface on the opposite side, the last sub-dimension should be omitted; and, also, an over-all dimension should be given from surface to surface.

Dimensions in Feet and Inches.

The common two-foot rule has undoubtedly been generally adopted for a standard when dimensions are given in feet and inches. Therefore all dimensions must be given in inches, including twenty-four inches and below. Dimen-

sions above twenty-four inches must be given in feet and inches.

Fig. 5, "F."

When dimensions are given in feet and inches, a dash one eighth of an inch long should separate them. Foot- and inch-marks not less than one sixteenth of an inch long should be used for accents. If there is a fractional number less than an inch, when the dimension is expressed in feet and inches, the figure zero should be placed before it. A fraction must never have a diagonal division-line, and the figures must be a little smaller than the integer which precedes it.

Dimensions in Decimals.
Fig. 5, "K."

When dimensions are given in decimals, the inch-marks should be placed between the whole number and fraction. If the decimal dimension is less than an inch, the figure zero should precede it and the decimal-point, and the inch-marks should be placed as indicated above.

Outside Diameter of a Gear.
Fig. 5, "G."

If the outside diameter of a gear is a fraction, it should be stated as a common fraction.

Reading Dimensions.
Fig. 5.

All dimensions should read from the bottom and right-hand side of drawing. If dimensions are at an angle with the edges of the sheet, they should read from bottom side of the drawing.

Mark Over Dimension Not to Scale.
Fig. 5, "K."

If a dimension is not to the same scale as others on the view, indicate it by a dash above the dimension.

Full Dimensions. Fig. 5.

Dimensions on a drawing should indicate the full dimensions independent of the scale of the drawing.

Final Dimensions.

All the dimensions given on a piece indicate the final dimensions of the piece when it is complete; and no allowance should be made for the shrinkage of casting, etc.

Radii or Diameters. Fig. 5, "H."

Care and judgment must be exercised as to whether the radii or diameters are the dimensions needed for the mechanic: *e.g.*, a bolt circle should have its radius given; a bored hole, its diameter given; a turned piece, its diameter given, etc.

A dimension should never be placed on a center line.

Never Cross a Dimension.

It is an inviolable rule to *never* cross a dimension with a line.

Small Rounds.

Small rounds on corners, or fillets, are not usually dimensioned.

Circles.

Circles which do not indicate clearly their relation to the piece shown in the view should never be dimensioned.

Rounded End of Screw. Fig. 5, "C."

If the end of a screw, stud, etc., is rounded, the dimensions should be given to the corner and not to the extreme end.

Standard Bolts, etc.

If bolts and screws are drawn, and everything is standard except their lengths, only the diameters of their bodies, the lengths under

the heads, and their lengths of thread, are shown in the dimensions.

Bolt Heads, etc. Fig. 29. Bolt-heads and nuts (when not standard), and square and hexagonal figures, should be dimensioned across flats and not across diagonals.

Rolled Structural Steel. Rolled structural steel should be dimensioned in the commercial sizes and not in every detail.

Rivet Holes, etc. Fig. 30. Where a number of rivet- or small bolt-holes are in a right line, the usual dimensions should be given in a note on the dimension-line between the first hole and the last hole. The note should give their number, size, distance apart, and the total distance from the first to the last hole. The dimension from one of the end holes to the end of the piece should be regularly given.

Sizes of Pipes. The sizes of pipes must be stated in their nominal inside diameters.

Pipe Tapped Holes. Pipe-tapped holes must be indicated by the size of pipe-tap required, and all other data regarding the hole are useless and should not be stated.

Board Dimensions. In giving board dimensions remember that the thicknesses of stock boards are more likely to be in fractional than in even inches; as, a seven-eighths of an inch instead of a one-inch board, and one and three-fourths inches instead of a two-inch board, etc.

Brick Dimensions.
Fig. 31.

Brick dimensions should be given in multiples of four.

Windows and Doors.
Fig. 8.

Windows in brick walls should be dimensioned to their centers, and doors should be dimensioned for the width of opening.

Dimensioning Angles.
Fig. 8.

When angles are given in degrees and minutes the usual degree and minute accents should be used, and a curved dimension-line should replace the usual right line. Otherwise the dimension-line conforms to the same rules as are observed for all dimension-lines.

Dimensions in Coordinates.
Fig. 32.

Dimensions of angles on a drawing intended for pattern-makers are often more convenient when given in coordinates from a given reference line or point, than when given in degrees and minutes.

Size of Dimension Figures.

As a rule the dimension-figures should be put in with as wide a line as the projection-lines.

Extension Lines.
Fig. 5.
Fig. 11.

Extension-lines are limiting lines that are used when a dimension is placed off the view, and must have the included distance between them equal to the same distance as referred to on the view. They should be fine, broken, parallel lines, composed of equal dashes spaced at equal distances, and no extension-line should join a projection-line.

Short Extension Lines.

Short extension-lines of one dash only can sometimes be used.

Notes.

Notes should be placed on a drawing so that they can be read easily and quickly.

Note in Horizontal Line. Fig. 5.

If convenience admits of it and there are several words in the note, they are more quickly read when placed in a horizontal line.

Uniform Lettering. Fig. 5.

All letters used in notes on drawings must be of the most simple type, plain, of uniform height, and composed of lines of uniform width to match the projection-lines of the object.

Initial Letter.

The initial letter of every word, excepting prepositions, should be taller than the others.

Size of Letters.

All the letters in a word should be close together and not less than one sixteenth of an inch nor more than one eighth of an inch in height.

Guide Lines.

Draw parallel guide-lines in pencil before printing words. All words should be sufficiently separated for clearness.

Written on Pencil Drawing.

All notes should be written on pencil drawings which are to be traced, and printed on inked or finished pencil drawings.

Notes must not be too abbreviated.

Short and Concise.

All notes must be in short sentences, explicit and concise.

Fig. 5, "A."

Castings and rough forgings are occasionally not finished all over; as a consequence, the custom in practice is to note the surfaces on each piece which are finished.

f Mark.
Fig. 5, "A."

When a surface is machined or finished an *f* mark should be placed on that line of the view which represents it, and not on the view where the blank surface only is shown.

Fin. All Over Mark.
Fig. 5, "H."

If a casting is finished all over, the several *f* marks should be left off, and the words *fin. all over* should be printed under or near the views.

Marking Lines of Finished Surfaces.
Fig. 33.

When there are two lines representing the edges of surfaces and one or both of them represent finished surfaces, the *f* marks should be placed outside and a curved dimension-line should be drawn from it to the finished surface.

State Kind of Finish.
Fig. 5, "K."

It is sometimes clearer, or necessary, to state the kind of finish or machining a piece should have, as *file-finish*, *grind*, *plane*, *bore*, etc.

Omit Finish Notes.
Fig. 5. "C."

Pieces which are made from rolled or wrought steel bars, as spindles, shafts, studs, etc., are usually finished all over, and it is the custom to omit the finish notes.

Steel Casting.

If a steel casting is wanted, do not confound it with cast steel, but call it a *steel casting* everywhere on the drawing.

Surface Partially Finished.
Fig, 34.

A large surface that is partially finished should be indicated to instruct the pattern-maker as to where the extra metal on the casting should be allowed.

Fixture or Jig Used.

If, in machining, a fixture or jig is used for any interchangeable part in a machine, it should be indicated by note on or near the view of the piece.

Threads Noted. Fig. 5, "F."

Threads should be noted in number per inch, unless they are U. S. Standard; in which case they should be indicated as such.

Taper on Shafts. Fig. 35.

Tapers on shafts should be given in inches per foot.

Springs. Fig. 5, "N."

Springs are described in detail by giving gage size of wire in a coil, the number of free coils to the inch, and the inside or outside dimensions of the body of the spring.

Wire.

The mesh of wire in screens is indicated by the size of wire to gage used, and the number per inch or the amount of opening between the wires.

Forced Fits.

Forced fits should be indicated by the total pressure required.

Inclination. Fig. 36.

The inclination of a pipe or a roof should be given as the *pitch* or *slope*.

Identifying Letter.

Every piece shown on a drawing must have an identifying letter, which should be a capital letter somewhat larger than the initial letters in the other notes on the drawing, and must be the same letter as used in the bill of material for the same piece. The letters I and J must not be used; and when the letters in the alphabet are exhausted, small capitals should be used along with and at the side of the large capitals.

Fig. 40.

Shade-lines, for outline shading, are sometimes used on edges and surfaces of views which conventionally cast shadows. They should not be used too freely, for they are a convention which adds to the work of the draftsman; but occasionally they make clearer the configuration of an intricate piece which is shown on a drawing, provided that the mechanic understands the convention as well as the draftsman who uses it. They are occasionally used for the purpose of display, which, at its best, in detail drawing is very much out of place. If, however, they are used on the views of one piece, they should be used on all the views of all the pieces which are shown on that one drawing, in order to conform to that fundamental rule of uniformity which should obtain in all drawings.

Outline Shading.

Outline shading should be done by drawing a second adjoining projection-line on and not outside that part of the view which represents the surface of the material. By drawing a shade-line, then, on the surface of the piece, it cannot be considered as a line in the shadow which is cast by an edge of an object, as it is often interpreted.

Shade Line.
Fig. 40.

By considering as a shade-line a line in the shade of the piece and not as a shadow cast

by it, the actual dimensions from edge to edge are kept to scale; and it follows that the lower and right-hand outside edges of a piece and the upper and left-hand edges of holes would have shade-lines.

Circle Shaded.

When a circle is shaded the set of the compass which strikes the circle should not be changed, but another center should be taken, up and along a line which makes 45° with the horizontal. The eccentric arc which is then struck with the new center to represent the shade-line should just join the original circle at the end of the 45° line, and it is then continued until it just merges with the original circle.

Round Piece.

In the side view of a round piece there is theoretically no outline shade-line on the round edge, but, by convention, a shade-line should be used.

Unsectioned Round Piece.

An unsectioned round piece in a bushing that is sectioned by a meridian plane has conventionally an outline shade-line.

V Thread Screw. Fig. 37.

In a V-thread screw, by convention, the short conventional thread-line is shown as a shade-line.

Sectional V Thread Nut. Fig. 37.

In a sectional V-thread nut, by convention, the long conventional thread-line is shown as a shade-line.

Pencil-drawings that are to be inked or traced over should never be outline-shaded.

Surface Shading. Fig. 40.

The views of the surfaces of pieces which are in the shade are occasionally shade-lined. Surface shading should be done to a very limited extent on commercial mechanical drawings, and only where it is quite necessary to make clear or stand out some surface which would otherwise be wholly confused in the view of an intricate piece.

No Surface Shading on Detail.

As a rule no surface shading should be used on any detail drawing.

Penciled Drawings.

When penciling a drawing, each piece, with all its views, should be completed before another is begun; and the penciling should be done in the following order:

1. Draw border-lines.
2. Draw match-lines.
3. Block out space for title.
4. Block out space for bill of material, if there is one.
5. Draw main center lines of object in all its views.
6. Draw projections of the main lines of the object.
7. Draw projections of the small and inside lines of the object, commencing with that view which shows the most essential features, if there is a choice.

8. Put in dimensions and necessary notes.

Free Hand Arcs. As large arcs as possible should be put in free-hand.

Appearance of Drawing. It is an art to make a finished pencil drawing neatly, quickly, and properly. With some draftsmen it appears to be a gift, but with others it must be acquired.

Pencil Completely. A drawing which is to be traced or inked should usually be completely penciled. It is an undesirable habit to form, and an unnecessary tax on the mind, when a draftsman leaves a large share of the details in his mind for inking, instead of penciling them on the drawing-paper.

Inked Drawings.

All drawings must be inked in with *black water-proof* drawing-ink.

To Ink a Drawing. The different parts of a drawing should be inked in the following order: first, all the lines of projection which are represented by the small arcs, the large arcs, and right lines taken in their respective order—and if there is any outline shading, it should be done at the same time; second, all auxiliary lines excepting hatch-lines; third, dimension-lines, arrow-heads, and notes; fourth, hatch-lines; fifth, surface shade-lines, if there are any; sixth, bill of material; seventh, title; eighth, border-lines.

Ink by Sections. It is sometimes well to ink only a section of a drawing at a time, particularly, if the drawing is not to be finished the same day that it is begun.

Trace by Sections. It is rather imperative that tracing-cloth should be inked in sections, as change of atmospheric conditions has a marked effect on the surface of tracing-cloth.

Work Across and Down. Always commence the inking at the top and left-hand side, and work across and down the sheet.

Wide Line. Any line which is over one thirty-second of an inch wide and drawn with a medium-size ruling-pen should be made with more than one stroke of the pen.

Narrow Sections. Fig. 38. When inking in the sections of very narrow walls in building plans or like sections, draw heavy parallel lines to represent their outlines, and fill in with the writing-pen or, preferably, a large ruling-pen.

Short Hatch Lines. Fig. 1. Hatch-lines which are three sixteenths of an inch long or less, should be put in with the writing-pen.

Uniformity. That which makes an inked drawing look well is uniformity in every detail, to wit, all figures, letters, lines, etc., that are used for like purposes should be of the same height, same width of line, and same style.

Checking Drawings.

Everything on a drawing must be thoroughly checked by at least two persons before it is allowed to pass into the shops.

Check by Steps.

A draftsman should check his drawing by methodical steps, and should not try to check it by taking a bird's-eye view of what he has done.

To Check a Drawing.

The following steps are to be observed in checking a detail drawing:

1. Identify every piece in its relation to the machine, and note if it is of proper form and that none are missing.

2. Check every view for correct and necessarily complete projections.

3. Note if there are any required dimensions or working notes missing.

4. Scale every dimension, and note if it agrees with the one given on the drawing.

5. Check the main dimensions of the pieces in detail and assembly and note if they agree.

6. Check the arrow-heads to see if there are any missing.

7. Check the accents to figures, as inch-marks, foot-marks, and degree-marks.

8. Check the center lines.

9. Check the supplementary notes and marks to see if they are correct and none missing.

Assembly Drawings.

Fig. 38.

The function of an assembly drawing is to show the arrangement of its principal parts in the most simple, direct, and comprehensive manner.

Outline, Section Lined.
Fig. 39.

An arrangement of parts is sometimes clearer when the main part has its outline fringed with a dotted section-line. That scheme, however, is not common at the present time.

Lines Near Together.
Fig. 38.

On a small scale it sometimes happens that several lines in true projection would be close together, and even merge if inked in. If such is the case, the line should be spaced a little farther apart or now and then one left out.

Elevations.

In assembly drawings show elevations in a line, if possible.

Minor Details.

Minor details, as, nuts, keys, set-screws, etc., can be left off the assembly drawing when they are evident without drawing.

Over All and Main Dimensions.

Over-all and important main dimensions are the most that are needed in an assembly drawing.

Structural Steel Parts.
Fig. 13.

Structural steel parts, when they are shown on such a reduced scale as to make a section one eighth of an inch or less in width, should be blacked in.

Bolts.
Fig. 40.

When there are four or more bolts in a piece, they should generally be shown, in a side view,

at their true scale distance from the center as measured each side of the center line.

Diagram Drawings.

Fig. 41. Fig. 42. If merely an outline of a machine or the kinematic relation of some of its parts is desired, a diagram drawing is made which is composed of the main lines of the machine with the usual center lines, or with heavy center line to show the kinematic relation of some of its parts.

In some intricate types of machinery, as shoe machinery, textile machinery, etc., and especially in textile machinery, it is often quite impossible to show, for an assembly drawing, anything more than a diagram drawing.

PATENT OFFICE DRAWINGS.

Fig. 43. A Patent-Office drawing must be made to certain specifications which are given verbatim as published in the official "Rules of Practice" in the United States Patent Office:

When the invention consists of an improvement on an old machine the drawing must exhibit, in one or more views, the invention itself disconnected from the old structure, and also, in another view, so much only of the old structure as will suffice to show the connection of the invention therewith.

Drawings must be made upon pure white paper of a thickness corresponding to three-sheet Bristol board. The surface of the paper must be calendered and smooth. India ink alone must be used to secure perfectly black and solid lines.

The size of a sheet on which a drawing is made must be exactly 10×15 inches. One inch from its edge a single marginal line is to be drawn, leaving the "sight" precisely 8×13 inches. Within this margin all work and signatures must be included. One of the shorter sides of the sheet is regarded as its top, and, measuring downwardly from the marginal line, a space of not less than $1\frac{1}{4}$ inches is to be left blank for the heading of the title, name, number, and date.

All drawings must be made with the pen only. Every line and letter (signatures included) must be absolutely black. This direction applies to all lines, however fine, to shading, and to lines representing cut surfaces in sectional views. All lines must be clean, sharp, and solid, and they must not be too fine or crowded. Surface shading, when used, should be open. Sectional shading should be made by oblique parallel lines, which may be about one twentieth of an inch apart. Solid black should not be used for sectional or surface shading.

Drawings should be made with the fewest lines possible consistent with clearness. By the observance of this rule the effectiveness of the work after reduction will be much increased. Shading (except on sectional views) should be used only on convex and concave surfaces, where it should be used sparingly, and may be even there dispensed with if the drawing is otherwise well executed. The plane upon which a sectional view is taken should be indicated on the general view by a broken or dotted line. Heavy lines on the shade sides of objects should be used, except when they tend to thicken the the work and obscure letters of reference. The light is always supposed to come from the upper left-hand corner at an angle of forty-five degrees. Imitations of wood or surface graining should not be attempted.

Scale of Drawing.

The scale to which a drawing is made ought to be large enough to show the mechanism without crowding, and two or more sheets should be used if one does not give sufficient room to accomplish this end; but the number of sheets must never be more than is absolutely necessary.

Letters of Reference.

The different views should be consecutively numbered. Letters and figures of reference must be carefully formed. They should, if possible, measure at least one-eighth of an inch

in height, so that they may bear reduction to one twenty-fourth of an inch, and they may be much larger when there is sufficient room. They must be so placed in the close and complex parts of drawings as not to interfere with a thorough comprehension of the same, and therefore should rarely cross or mingle with the lines. When necessarily grouped around a certain part they should be placed at a little distance where there is available space, and connected by short broken lines with the parts to which they refer. They must never appear upon shaded surfaces, and when it is difficult to avoid this a blank space must be left in the shading where the letter occurs, so that it shall appear perfectly distinct and separate from the work. If the same part of an invention appears in more than one view of the drawing, it must always be represented by the same character, and the same character must never be used to designate different parts.

Signature of Inventor and Witnesses.

The signature of the inventor should be placed at the lower right-hand corner of each sheet, and the signatures of the witnesses at the lower left-hand corner, all within the marginal line, but in no instance should they trespass upon the drawings.

Title.

The title should be written with pencil on the back of the sheet. The permanent names and title will be sup-

plied subsequently by the office in uniform style.

Large Views.

When views are longer than the width of the sheet, the sheet should be turned on its side, and the heading will be placed at the right and the signatures at the left, occupying the same space and position as in upright views, and being horizontal when the sheet is held in an upright position; and all views on the same sheet must stand in the same direction.

As a rule, one view only of each invention can be shown in the Gazette illustrations. The selection of that portion of a drawing best calculated to explain the nature of the specific improvement would be facilitated and the final result improved by the judicious execution of a figure with express reference to the Gazette, but which might at the same time serve as one of the figures referred to in the specification. For this purpose the figure may be a plan, elevation, section, or perspective view, according to the judgment of the draftsman. It must not cover a space exceeding 16 square inches. All its parts should be open and distinct, with very little or no shading, and it must illustrate the invention claimed only, to the exclusion of all other details. When well executed it will be used without curtailment or change, but any excessive fineness, or crowding, or unnecessary

elaborateness of detail will necessitate its exclusion from the Gazette.

An agent's or attorney's stamp, or advertisement, or written address will not be permitted upon the face of a drawing, within or without the marginal line.

INDEX.

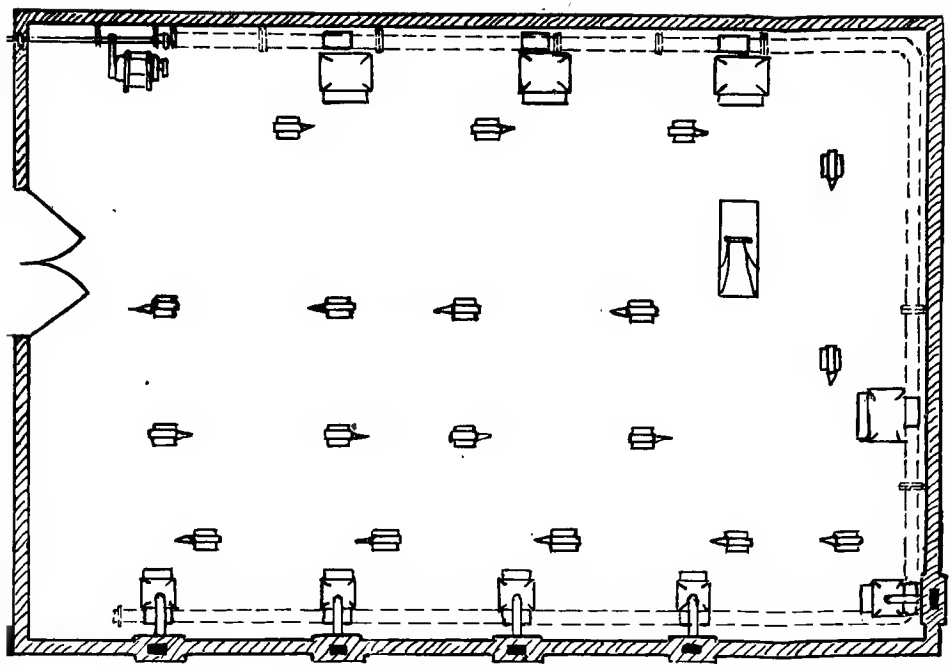


FIG. 1

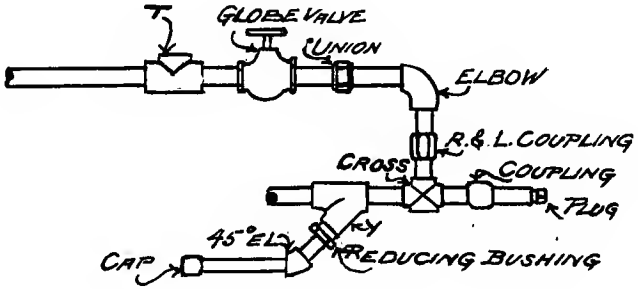


FIG. 2

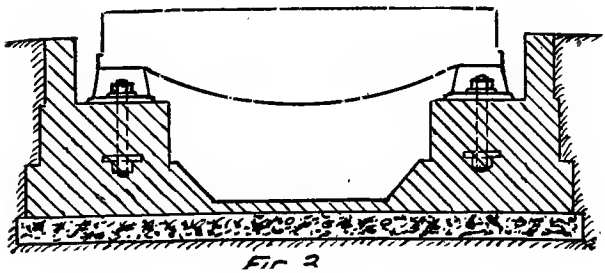


FIG. 3

ABCDEFGHIJKLMNOPQRSTUVWXYZ &1234567890

abcdefghijklmnopqrstuvwxyz

ABCDEFGHIJKLMNOPQRSTUVWXYZ &1234567890

abcdefghijklmnopqrstuvwxyz

ABCDEFGHIJKLMNOPQRSTUVWXYZ 1234567890

abcdefghijklmnopqrstuvwxyz

ABCDEFG

OPQRSTU

12345

ASSEMBLY

16 IN. ENGINE LATHE

M.D. DEPT. SIBLEY COLLEGE

ITHACA N.Y.

SCALE: 3 INS = 1 FT.

DATE NAME

HIJKLMN

VWXYZ&

67890

Details

Bed for 16in. Engine Lathe

Mach. Design Dept Sibley College

Ithaca New York

Scale: 1½ ins = 1 ft.

Date Name

F-7

ASSEMBLY

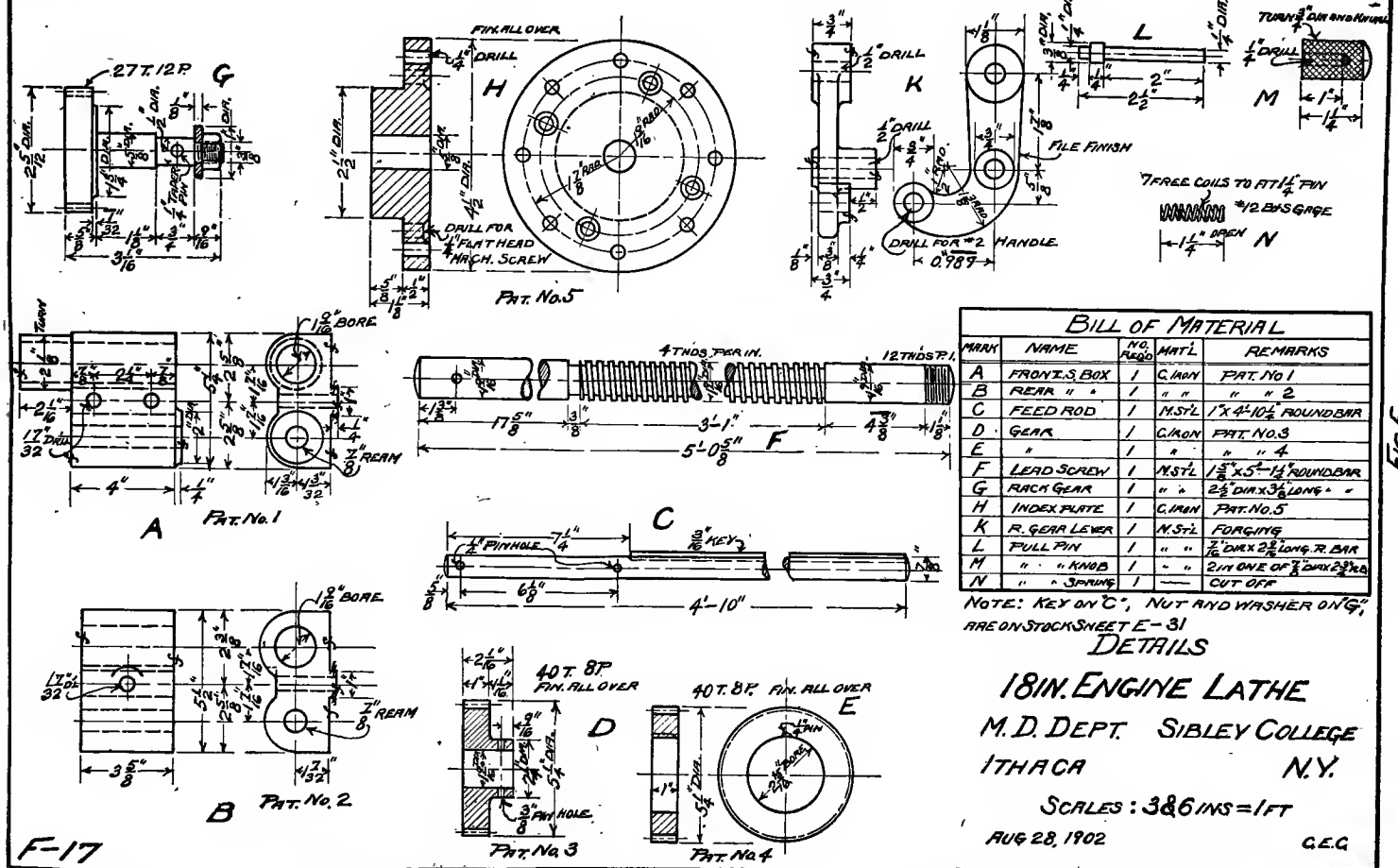
16 IN. ENGINE LATHE

M.D. DEPT. SIBLEY COLLEGE

ITHACA N.Y.

FULL SIZE

DATE NAME



BILL OF MATERIAL				
MARK	NAME	NO. REQ'D	MAT'L	REMARKS
A	FRONT S. BOX	1	C. IRON	PAT. NO 1
B	REAR " "	1	" "	" " 2
C	FEED ROD	1	M.S. STL	1" X 4 1/2 - 10 1/2 ROUND BAR
D	GEAR	1	C. IRON	PAT. NO. 3
E	"	1	"	" " 4
F	LEAD SCREW	1	M.S. STL	1 3/8" X 5 1/2 - 1 1/4" ROUND BAR
G	RACK GEAR	1	" "	2 1/2" DIA. X 3 1/2" LONG " "
H	INDEX PLATE	1	C. IRON	PAT. NO. 5
K	R. GEAR LEVER	1	M.S. STL	FORGING
L	PULL PIN	1	" "	7/16" DIA. X 2 3/16 LONG R. BAR
M	" " KNOB	1	" "	2 IN ONE OF 7/8" DIA. X 2 3/16 LG.
N	" " SPRING	1	———	CUT OFF

NOTE: KEY ON "C", NUT AND WASHER ON "G", ARE ON STOCK SHEET E-31

DETAILS

18 IN. ENGINE LATHE

M. D. DEPT. SIBLEY COLLEGE

ITHACA N.Y.

SCALES: 3 & 6 INS = 1 FT

AUG 28, 1902 G.E.C.

F-17

FIG 5

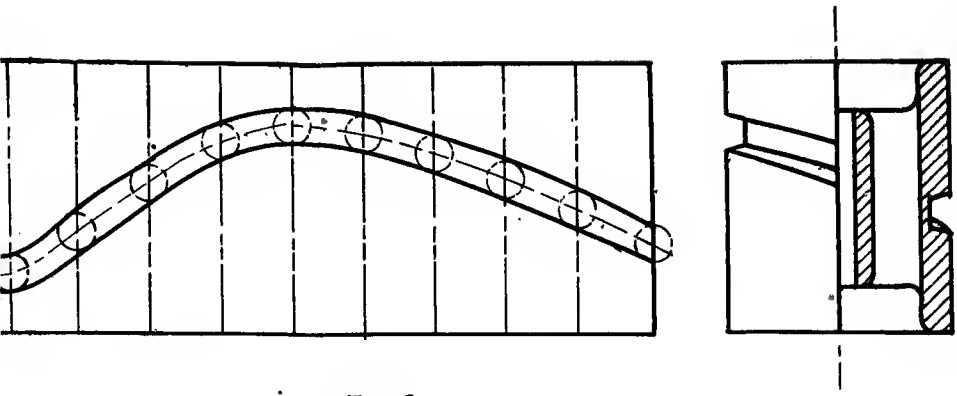
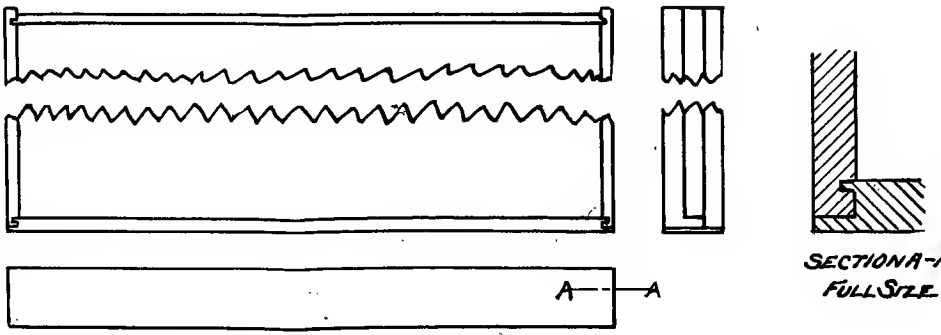


FIG. 6



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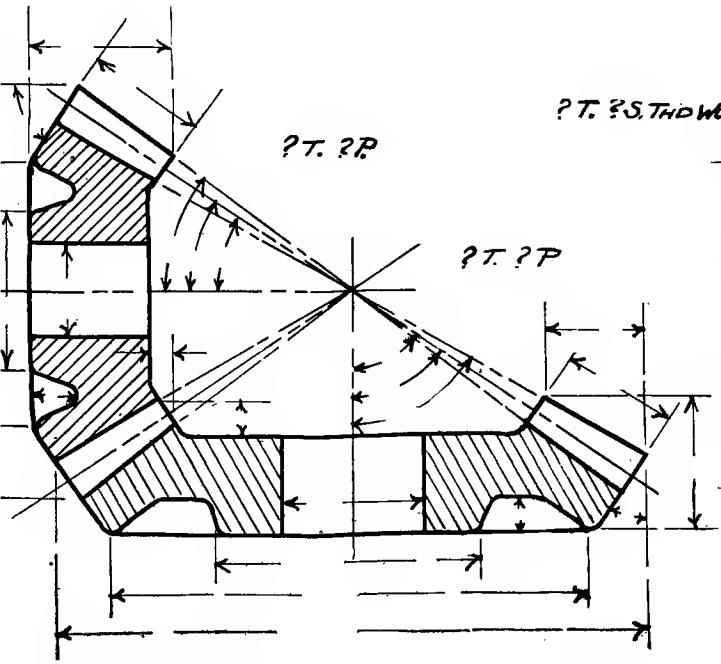

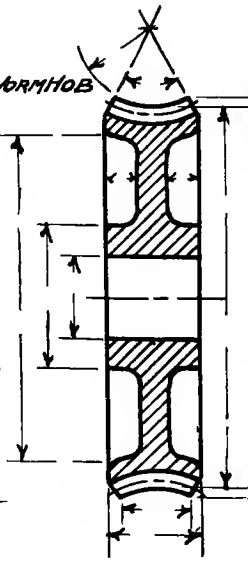

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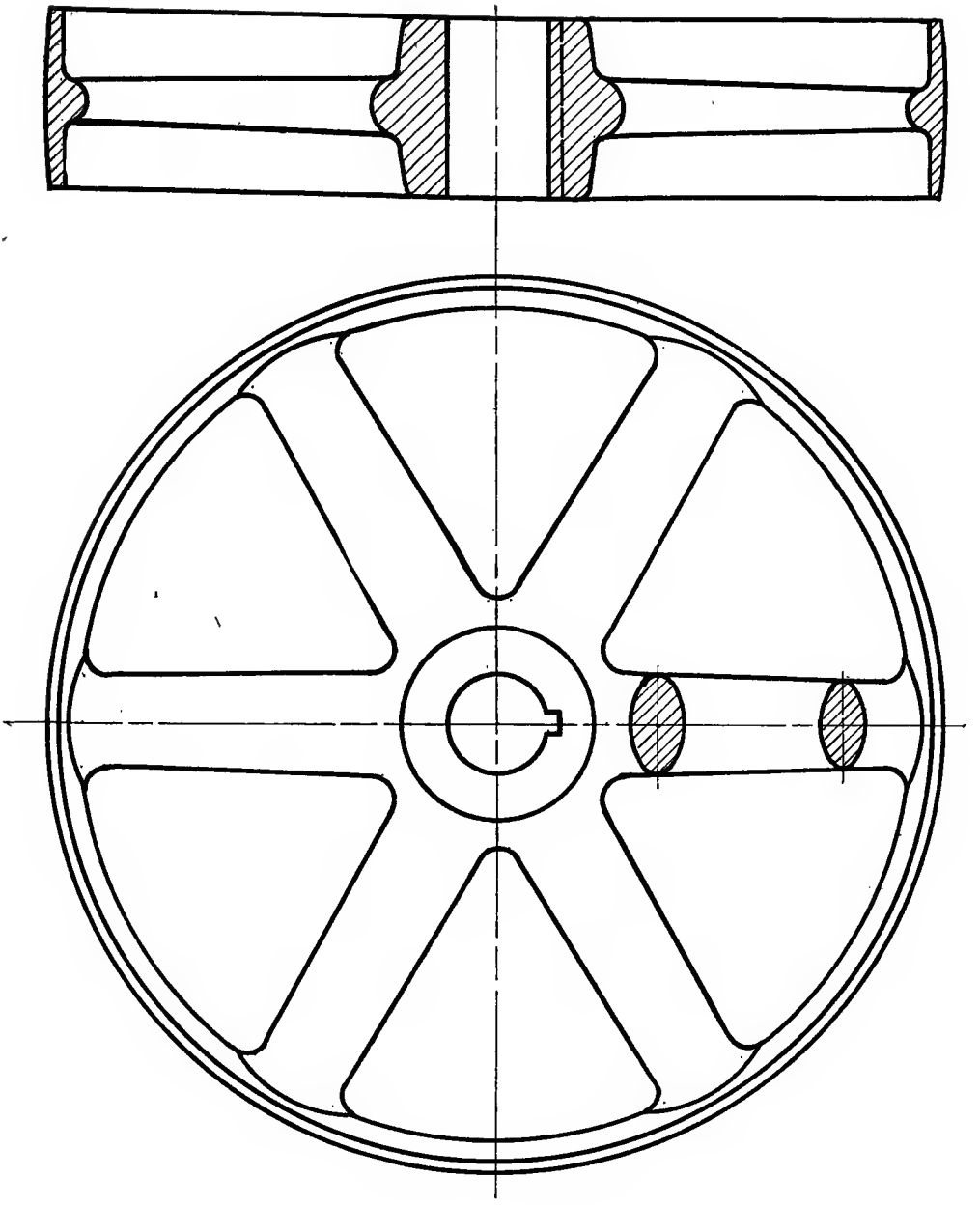

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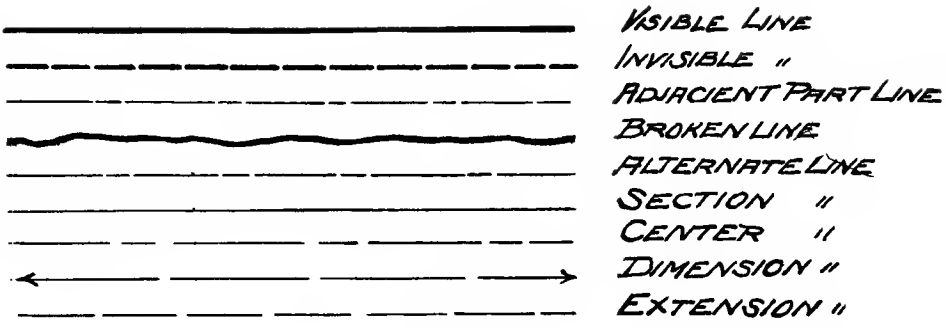

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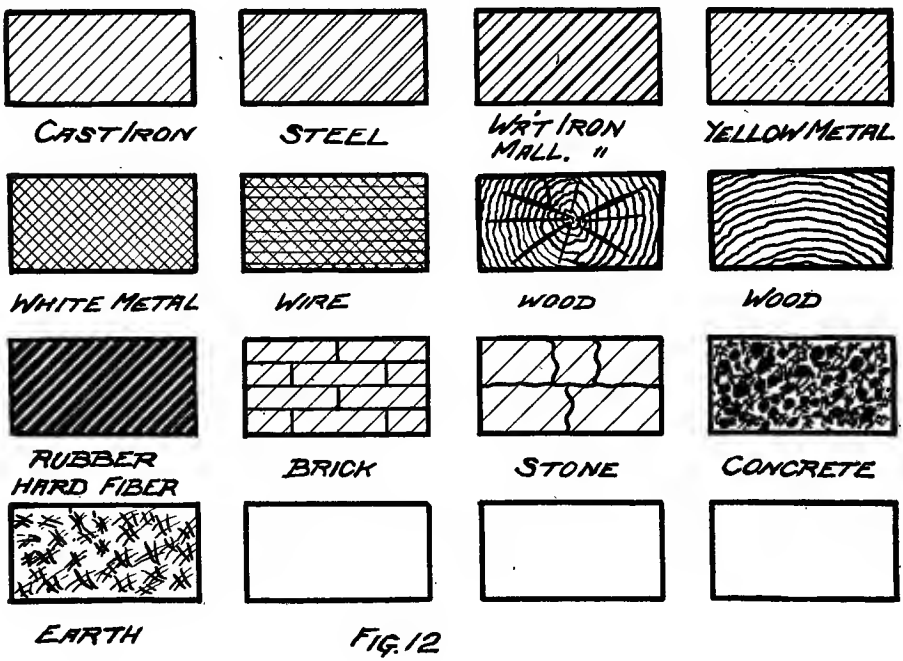

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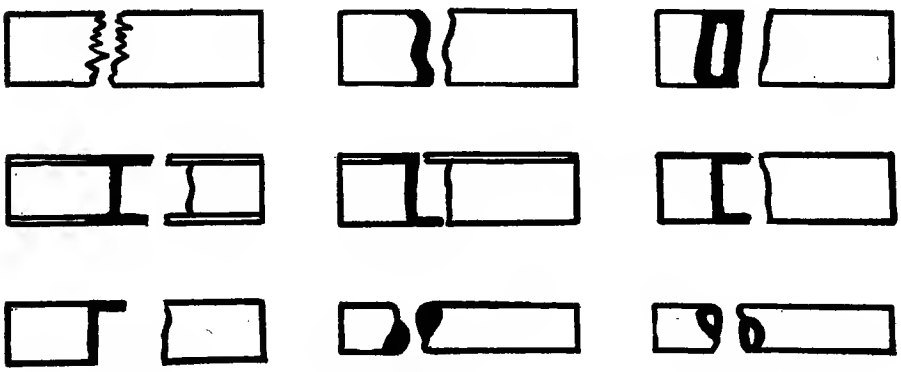

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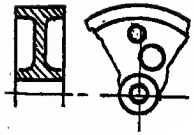
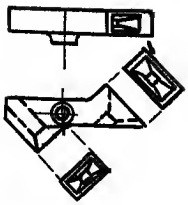


FIG. 14



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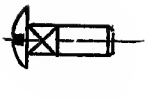

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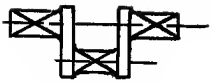


FIG. 17

FIG. 18

FIG. 19

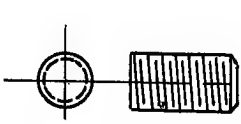


FIG 20

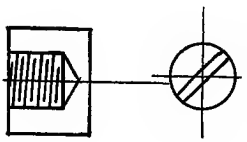


FIG 21

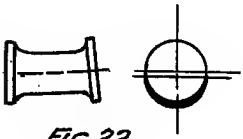
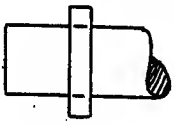


FIG 22



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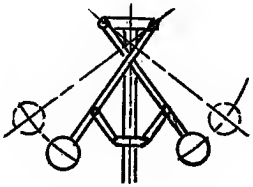


FIG. 24

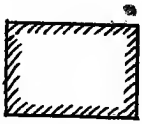


FIG. 25

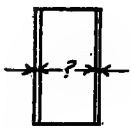


FIG. 26

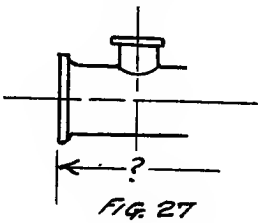


FIG. 27

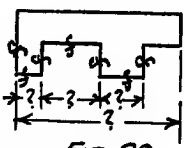


FIG. 28

FIG. 29

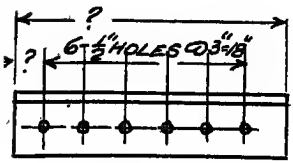


FIG. 30

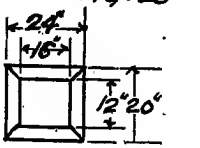


FIG. 31

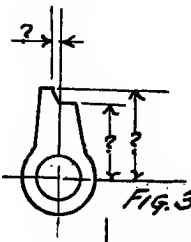


FIG. 32

FIG 33

FIG. 34

FIG. 35

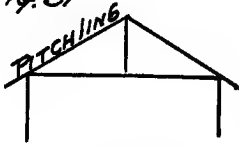


FIG. 36

FIG. 37

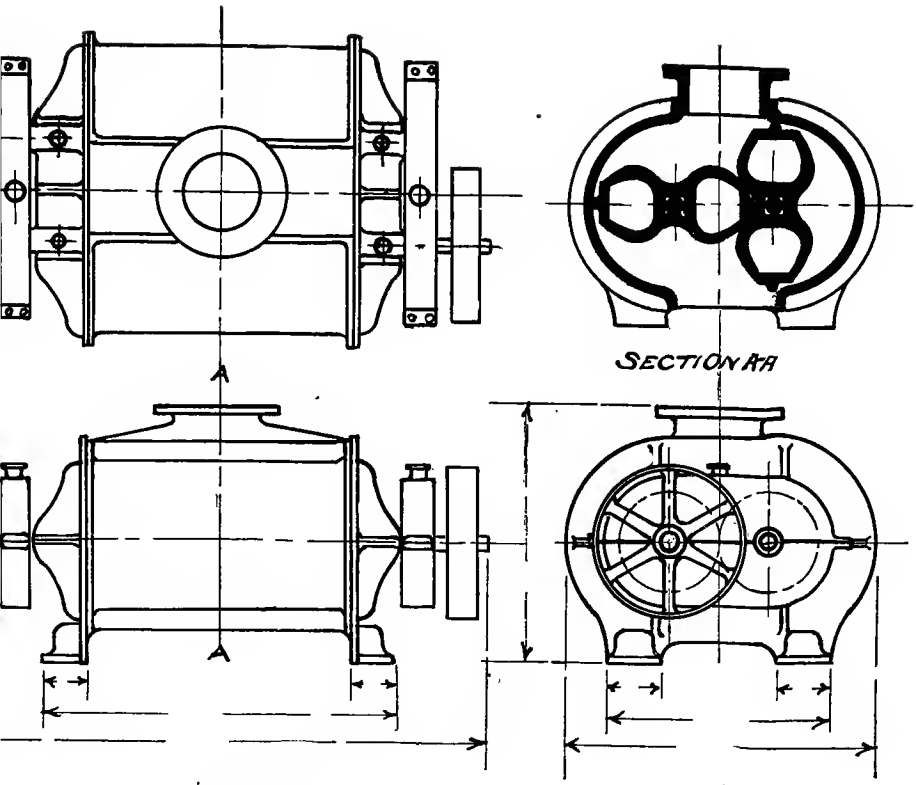
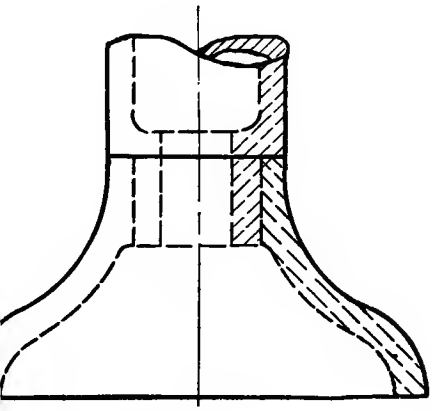


FIG. 38



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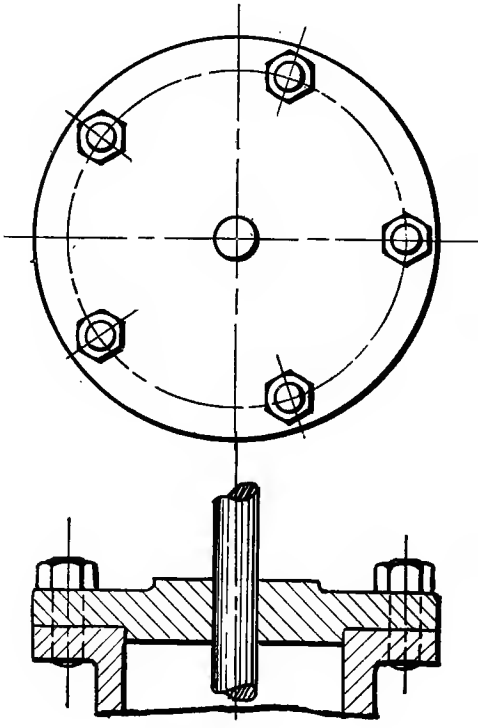

FIG. 40

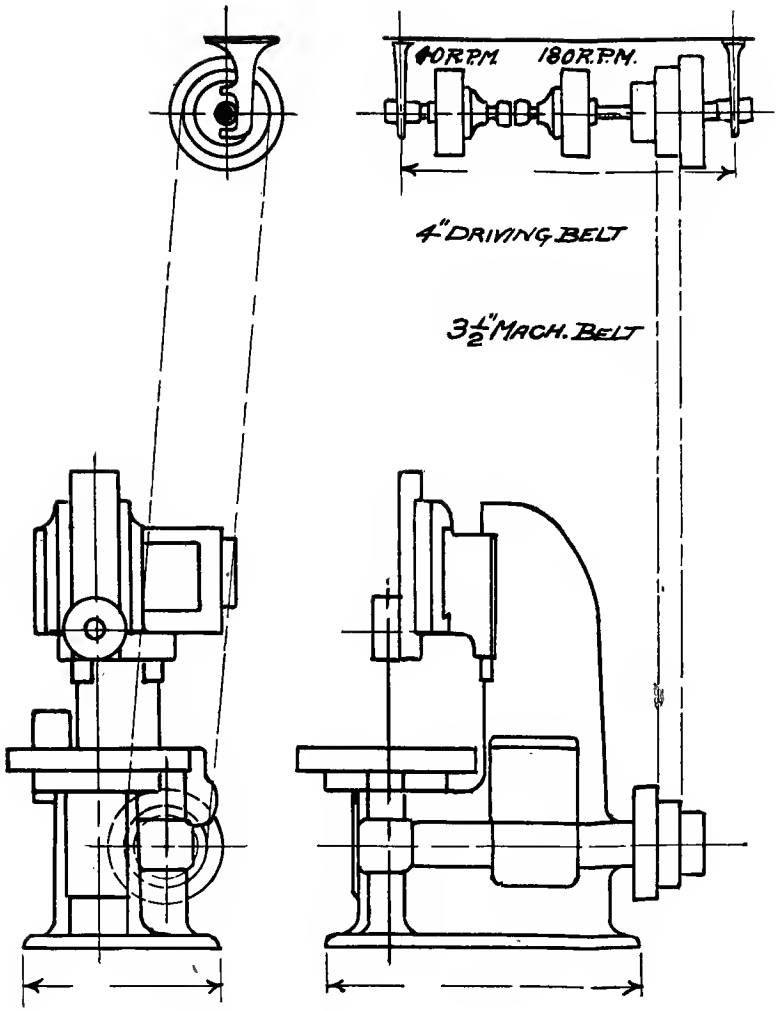

FIG. 41

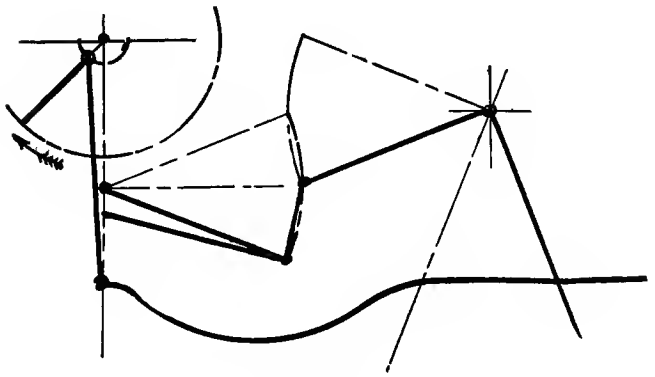

FIG. 42

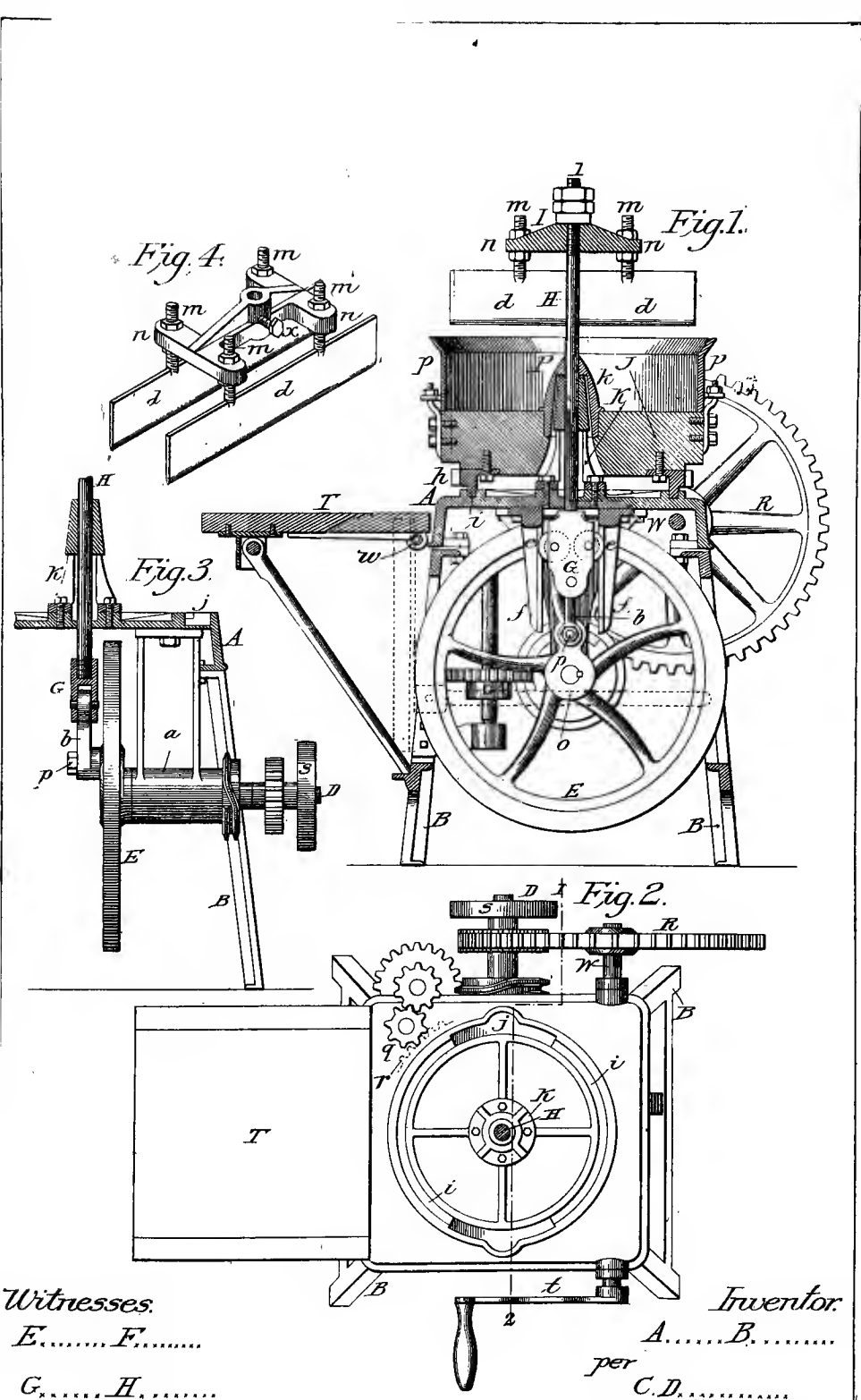
Fig. 4.
Fig. 1.
Fig. 3.
Fig. 2.
Witnesses.
E..... F.....
G..... H.....
Inventor.
A..... B.....
per
C.D.....
Attorney.